

BBC

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# Knowledge

SCIENCE • HISTORY • NATURE • FOR THE CURIOUS MIND

## HOW WE'LL BUILD A REAL **JURASSIC** WORLD

How science will bring extinct  
creatures to a theme park near you p42



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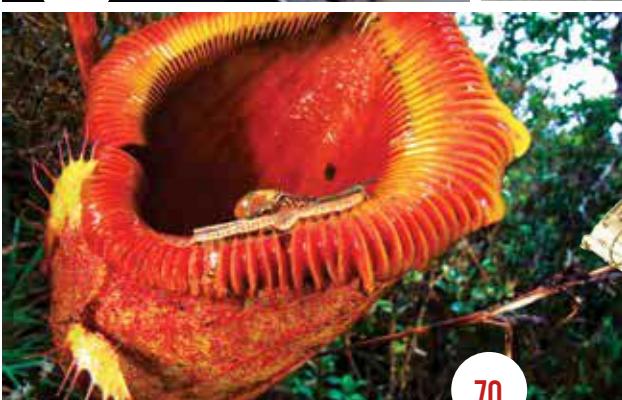
Knowledge reveals the science it would take to bring extinct animals back to life



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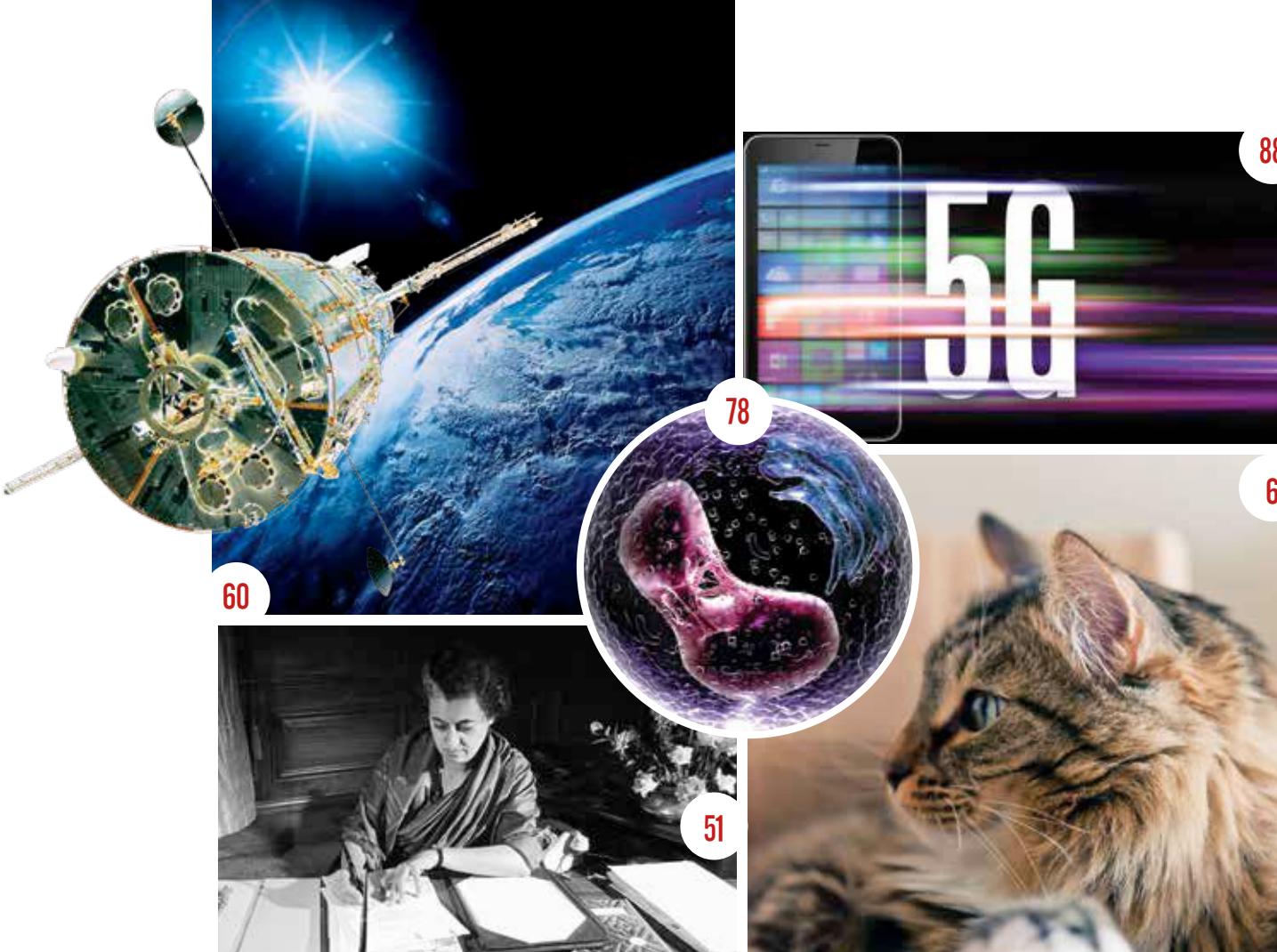
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# FROM THE EDITOR



I am just going to say it outright. I love dinosaurs, but I am not sure if I want to see them come back to life. I am the thrill loving kinds; I really am, but I am also a supporter of ethical science practices and research. So give me a good discussion and an argument first. I am sure most would agree that nature's selection and evolution process is way more wise and intensive than the genius of man. And the decision to bring back that, which has become extinct, or to create life artificially, should not be an easy one to make.

Just because we can, doesn't mean we should; these oft-said words (also a line in the just-released *Jurassic World*) symbolise a philosophical and an ethical dilemma. And like all such dilemmas, this too does not have a clear-cut answer. As ethics go, absolute rights or wrongs are confirmed only when mass behaviour patterns get accepted as social norm. Centuries ago, certain crimes were not considered as sin as they are considered now. Dolly the sheep; the world's first cloned mammal (1996), caused a huge social uproar. It was outrageous, wrong and unnatural, they said. Twenty years down the line, cloning still remains a highly contentious and controversial issue but research has already made huge strides in the field of genetic sciences.

Genetically modified foods in some form or the other are consumed all over the world. There is still data and sentiment that opposes GM products but there is more acceptances now than there was before. My point is, this is social behaviour and social mandate, with its tugs and pushes. And slowly as time passes, societies and communities give a verdict whether they accept something or not. Maybe one day, soon in the near future, genetically modifying DNA to create a newer specimen won't remain as big an ethical dilemma.

Which brings us to dinosaurs. Did you see the movie? The only big question I came back with after seeing it, was why did they not have a contingency plan. Don't you think? ☺

But seriously, we would love to hear your thoughts on 'Just because we can, does it mean we should'? Write to us at [edit.bbcknowledge@wwm.co.in](mailto:edit.bbcknowledge@wwm.co.in)

Happy reading this month's edition.

Lutisha Singh

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## EXPERTS THIS ISSUE



**Bill McGuire** is Emeritus Professor of Geophysical and Climate Hazards at University College London. He is a science writer and academic who served on the UK Government Natural Hazard Working Group. In this issue, he digs into the history of the greatest volcanic eruption ever and explores the chances of a repeat occurrence.

*See page 26*



**Dani Jimenez** is a Spanish physicist and a lover of practical science. He runs his own webseries called CreaCienca, which shares scientific knowledge through fun experiments. In this issue, we look at the stunning results of some of these experiments. *See page 32*



**Christian Ziegler** is a renowned photojournalist who regularly contributes to National Geographic and other publications. He specialises in nature photography. In this issue, we look at his shots of predatory plants. *See page 70*



**Katherine Nightingale** is a science writer who has written for publications as diverse as Focus, Australian Geographic and ABC Health & Wellbeing. She holds a Masters degree in molecular and cellular biology and science communication. In this issue, she traces our knowledge of the human cell. *See page 78*



## SEND US YOUR LETTERS

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# Q&A

## EXPERT PANEL

**Susan Blackmore (SB)**  
A visiting professor at the University of Plymouth, UK, Susan is an expert on psychology and evolution.

**Alastair Gunn**  
Alastair is a radio astronomer at Jodrell Bank Centre for Astrophysics at the University of Manchester, UK.

**Robert Matthews**  
Robert is a writer and researcher. He is a Visiting Reader in Science at Aston University, UK.

**Gareth Mitchell**  
As well as lecturing at Imperial College London, Gareth is a presenter of *Click* on the BBC World Service.

**Luis Villazon**  
Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground*.

## ASK THE EXPERTS?

Email our panel at [bbcknowledge@wwm.co.in](mailto:bbcknowledge@wwm.co.in)  
We're sorry, but we cannot reply to questions individually.

### VITAL STATS

750

Is thought to be the max. number of mature European sturgeon in the wild. In the worst case scenario, the figure may be as low as 20

Where is the loudest place in the Universe? p8 • What's the difference between an internet meme and a teme? p9 • How do rats survive the toxic gases in sewers? p10 • Can fingerprints change during a lifetime? p11 • Why does turning a device off and on often solve issues? p13

## How much salt does it take to poison an adult?

The medical literature lists an estimated lethal dose of between 0.75g and 3g per kilogramme of body weight. For a 75kg adult, that means a minimum of 56g of salt or about 10 teaspoons, taken all at once. But salt poisoning is about the concentration of salt in your blood, not the amount that you eat. Your body will remove excess salt through your kidneys and your sweat. If you have access to plenty of fresh water, you can cope with a much higher salt dose than if you are dehydrated. LV



Mmm... just about the right amount for our chips

## What do dogs hear when we talk to them?

There's good evidence that dogs can recognise many of the subtleties of human speech. A 2014 study at the University of Sussex found that dogs use the right side of their brain for processing the emotional content of speech, such as tone of voice, and the left side for verbal commands. Dogs can tell when a recognised command word is given, even when said with an unfamiliar accent. And they can tell the difference between correct commands, such as "Come on, then," compared to one with jumbled syllables, "Thumb on, Ken!" LV



Ate the Sunday roast?  
Me? Never!



There's a serious  
glitch in The Matrix.

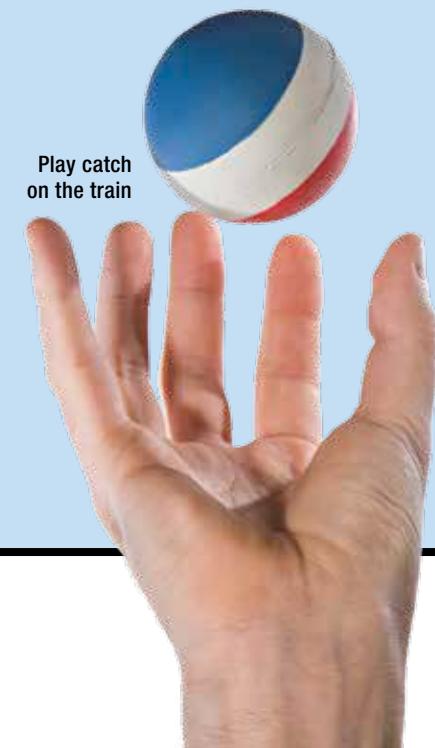
## Can déjà vu be explained?

The phenomenon of déjà vu is a sudden and intensely convincing feeling that you've been somewhere before, or that it has happened before. Many people jump to the conclusion that they dreamt the scene and now it's coming true. But there are no documented cases of people, in this state, predicting what's going to happen next. And many attempts to prove precognitive dreams have failed. An old theory is that déjà vu happens when one part of the brain senses something fractionally before another

part, wrongly setting off the feeling of familiarity. Another blames excessive or unusual temporal lobe activity. The temporal lobes handle many memory functions and are responsible for the sense of familiarity. Temporal lobe epileptics often report déjà vu. People with highly variable temporal lobe activity tend to be creative, believe in the paranormal and have lucid dreams, spiritual and out-of-body experiences as well as déjà vu. Next time you get this feeling, blame your temporal lobes. SB

## If I throw a ball up vertically in a moving train, will it move away from me?

No – it will land just as if you were standing still. That's because the ball started off in your hand, so was also travelling forward with the speed of the train. Once airborne, it doesn't lose that forward speed, so it keeps up with you and lands in your hand. RM



Play catch  
on the train



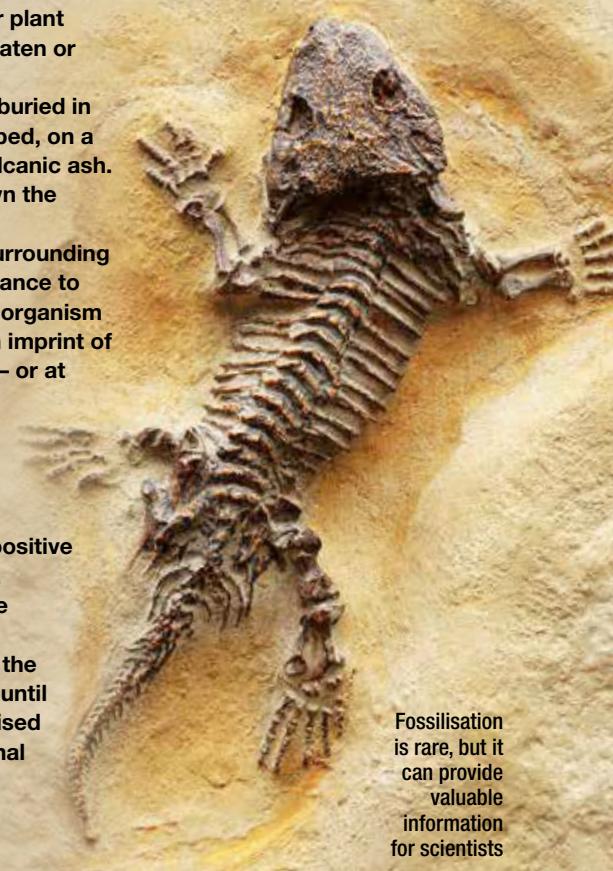
If I fits, I sits

## Why do cats like boxes?

Wolves, eagles, jackals, foxes and snakes prey on wild relatives of the cat. Cats hide in bushes or burrows during the day to escape their predators and to go to sleep. This behaviour lingers in domestic cats. A study at the University of Utrecht in the Netherlands found that cats in animal shelters were much less stressed by their new surroundings if they had a box to hide in. Even when cats aren't stressed, a box feels more secure, cosy and comforting. LV

## How do fossils form?

When an animal or plant dies, it is usually eaten or rots away. But it occasionally gets buried in the silt on the seabed, on a riverbank or by volcanic ash. This can slow down the decay processes enough that the surrounding sediment has a chance to harden before the organism decays, leaving an imprint of the animal's body – or at least its bones. More rarely, other minerals might percolate into the body tissues and harden to form a positive cast of the animal. Fossils can also be squeezed at great pressure between the layers in the rock, until only a thin carbonised smear of the original tissues is left. LV



Fossilisation is rare, but it can provide valuable information for scientists

## Where is the loudest place in the Universe?

Sound is the movement of a pressure wave through matter. Since space is almost (but not quite) a complete vacuum, sound does not propagate easily through it. However, where matter is denser, such as in the atmospheres of planets, within stars, in gas clouds or in environments surrounding black holes, sound waves are thought to be common.

The 'loudest' sounds in the Universe are the ones carrying

most energy. A rough estimate of the loudness of the Big Bang is about 100dB to 120dB. Although this is near the human ear's pain threshold, it is by no means the loudest thing known to us. It is estimated that the loudest thing on Earth was probably the explosion of the Tunguska Meteor (1908) at about 300dB. Perhaps where planets or black holes collide, or where supernovae explode, there may be sounds more powerful than this. AG



Some 80 million trees were flattened following the Tunguska Meteor impact

## Why is 48 hours' growth of facial hair so uncomfortable?

Beards grow by about half a millimetre a day. For the first 24 hours, your beard is just climbing back out of the follicles and barely pokes clear of your chin. Once the hairs get a little longer they can rub against nearby skin, particularly under your chin and on your neck where the skin wrinkles up as you move your head. As your beard gets longer, the hairs bend more and are less likely to stab your skin. LV

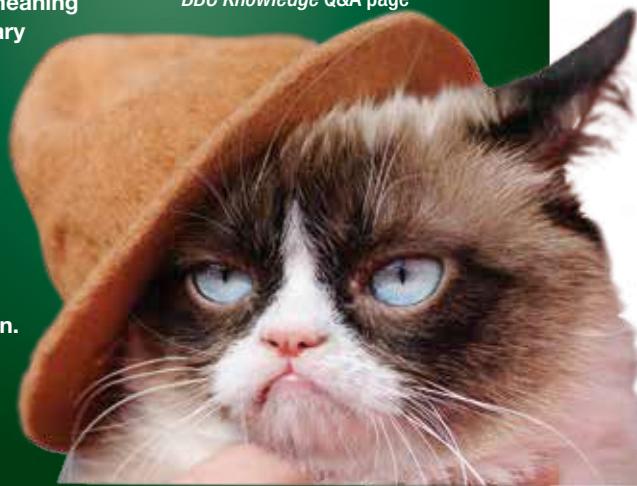


## What's the difference between an internet meme and a teme?

Internet memes are created, copied and selected by us. Darwinism claims that when any kind of info is copied, varied and selected then evolution must happen. This information is called a 'replicator'. Genes were the first replicator on Earth, and memes the second. Memes appeared when early humans began to imitate, meaning they could copy, vary and select ideas, skills, stories and technologies. Digital technology may be allowing a third replicator, temes, to emerge – digital info that evolves without intervention. We created the machinery that

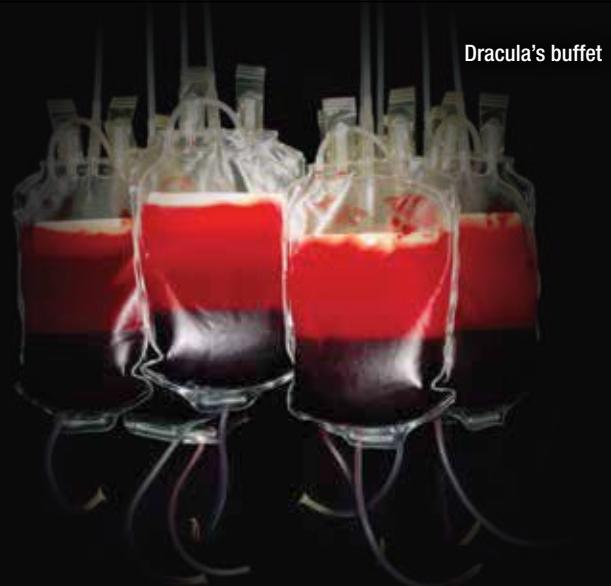
makes this possible but are no longer in control of it. This idea may or may not be valid, but it helps us think about the evolution of all that stuff in the web. SB

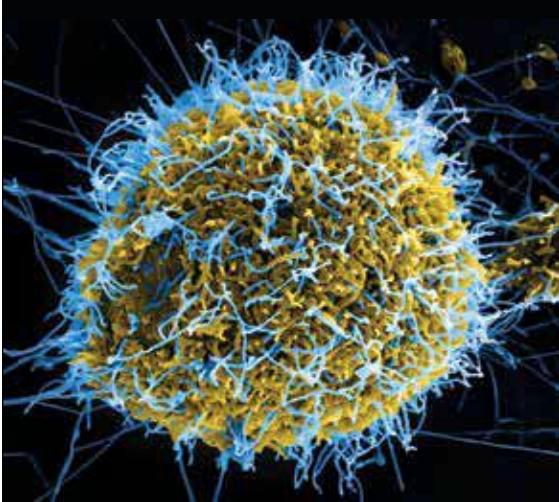
Grumpy Cat disapproves of the BBC Knowledge Q&A page



## Why does the human body reject transplanted organs but not blood transfusions?

Blood transfusions are rejected, if incompatible blood types are mixed. But donated blood is normally centrifuged to separate out the different components. In an ordinary blood transfusion, all you're receiving is the red blood cells. Apart from a few extremely rare cases, everyone's red blood cells fall into four main groups (A, B, AB and O). This makes it much simpler to match donor and recipient – and in emergencies, you can safely give type O negative blood to anyone. Organ tissues have compatibility types determined by much more complicated genetics with thousands of possible combinations, so finding a good match from unrelated donors is much less likely. LV





## How does a virus mutate so quickly?

Not all viruses do mutate quickly. DNA viruses, like smallpox, have mutation rates that are roughly the same as bacteria and other microorganisms. But viruses that use the single-stranded RNA, instead of DNA's double helix as their genetic material, mutate over 100 times faster. On average, an RNA virus mutates one letter of its genetic code almost every time it replicates. They do this by not proofreading their work.

In contrast, DNA-based organisms have special enzymes that spot errors and redo that section of DNA, but RNA viruses lack this. This may be an adaptation to allow them to make lots of hasty, inaccurate copies of themselves to overwhelm their host before the immune system is able to respond. Most mutations are bad for a virus, so RNA viruses are limited to very small genomes to give them a decent chance of making an error-free copy. LV



Amphibians may be able to detect changes in groundwater prior to earthquakes taking place

## Can animals sense an impending earthquake?

When an earthquake strikes, different vibrations travel through the ground at different speeds. The Primary (P-wave) vibrations travel about twice as fast as the Secondary (S-wave) vibrations that do most of the actual shaking. P-waves are generally too subtle to be felt by humans, although seismographs will pick them up. But some animals may be able to detect P-waves before the S-waves arrive. This would give them less than two minutes' notice for any quake near enough to affect them.

Stories of snakes leaving their burrows, dogs barking excessively or birds flying in unusual patterns, days or weeks before an earthquake actually takes place are more contentious.

But there may be subtle changes prior to an earthquake that animals are able to detect. A 2011 study at The Open University found that the stresses that build up along earthquake fault lines cause pockets of positive charge to move through the rocks to the surface and will trigger chemical changes in the groundwater. This could have been the reason that toads suddenly left their breeding pond a few days before the earthquake that hit L'Aquila, Italy in 2009. Their pond was 74km away from the earthquake's epicentre.

The positive charge could even affect the electromagnetic fields that bats and birds use for navigation, but we don't have any direct evidence for this yet. LV

## How do rats survive the toxic gases in sewers?

The most toxic component of sewer gas is hydrogen sulphide (H<sub>2</sub>S), which is produced by bacteria decomposing organic matter in oxygen-starved environments. H<sub>2</sub>S is deadly to humans at concentrations as low as 300 parts per million. The lethal concentration for rats is about 1.5 times higher, but they probably just try to avoid gas pockets. H<sub>2</sub>S is heavier than air, so it collects in the lowest part of the sewer system. Some humans can detect its rotten egg smell at concentrations of just five parts per billion. LV



## Will supersonic flights ever make a comeback?

Within at least the next generation, the answer has to be 'very unlikely'. To understand why, one hardly needs to look further than the Airbus A380. The trend in aviation is to increase efficiency of aircraft, not speed. It's partly an equation of bigger planes, and thus less energy per passenger per kilometre. But the massive A380 also gains economies with its light carbon fibre frame, advanced avionics and engines with large air intakes that burn fuel more efficiently than smaller turbofans. Yet firms such as the UK's HyperMach believe

they can achieve hypersonic speeds at subsonic efficiencies by cruising at twice the altitude of conventional aircraft where the air is thinner. Hypersonic is faster than supersonic, and is generally defined as Mach 5 and above.

HyperMach plans to fly a prototype of its SonicStar plane in 2023. But even then, it will not quite be the beginning of fast air travel for the masses. The first planes would be executive jets, which would open up two-hour Atlantic crossings – but only to the mega rich. GM

The SonicStar will hold no more than 20 passengers. You can guarantee one will be a screaming baby

## Can fingerprints change during a lifetime?

The pattern of loops and whorls on your fingerprints was fixed three months before you were born. You can scar your fingerprints with a cut, or temporarily lose them through abrasion, acid or certain skin conditions, but fingerprints lost in this way will grow back within a month. As you age, skin on your fingertips becomes less elastic and the ridges get thicker. This doesn't change your fingerprint, but it's harder to scan or take a print from it. LV

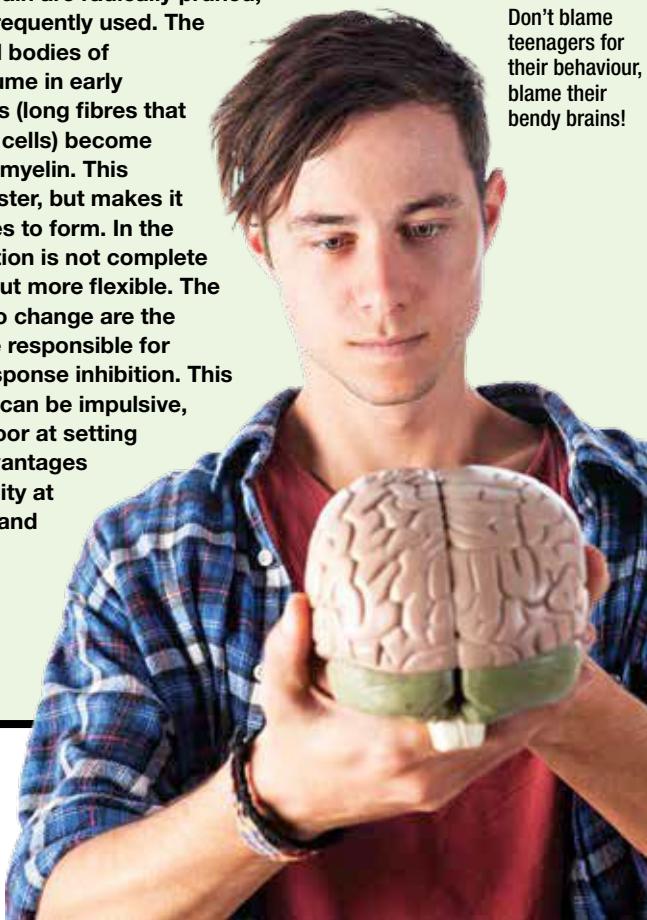


My, what lovely prints you have!

## How does a teenage brain differ from an adult brain?

A teenage brain doesn't grow as fast as a child's, but its organisation keeps changing right up to the early 20s.

Synapses in the teen brain are radically pruned, leaving only the most frequently used. The brain's grey matter (cell bodies of neurones) peaks in volume in early adolescence. The axons (long fibres that communicate between cells) become gradually covered with myelin. This makes signals travel faster, but makes it harder for new synapses to form. In the teenage brain, myelination is not complete so the brain is slower but more flexible. The last parts of the brain to change are the frontal lobes, which are responsible for impulse control and response inhibition. This may explain why teens can be impulsive, easily distracted and poor at setting sensible goals. The advantages of this may lie in flexibility at a time of rapid change and adaptation. SB



Don't blame teenagers for their behaviour, blame their bendy brains!

## Why do we close our eyes when we're trying to remember things?

To avoid distraction. When we imagine something, our brains use the same systems they use for seeing, touching or listening. If you're trying to recall a past event, you need to free up the visual cortex to conjure up the images.

Researchers asked people to watch a short video and then answer questions about it. Those who closed their eyes or looked at a blank screen remembered more than those who watched a display of nonsense images or heard unfamiliar words. In other tests, they had to recall details from a crime video with their eyes open or closed. They remembered more correctly with their eyes closed. They also recalled sounds from the video better when their eyes were shut. SB

# QUESTIONS AND ANSWERS

## Is there a way to walk across slippery surfaces without falling?

Recent research at the Salk Institute for Biological Sciences in California found that we balance on slippery or narrow surfaces using clusters of ROR $\alpha$  neurones in the spinal cord. These ‘mini brains’ process the huge amount of sensory information coming from your skin, muscles, inner ear and eyes and make hundreds of tiny corrections per second. It’s a bit like the ABS in your car constantly watching for a skid and pumping the brakes before it happens. You can also reduce your chances of a fall by copying penguins. When you walk normally, your centre of gravity is only directly above the weight-bearing foot for a small part of each stride. If you waddle from side to side instead, your centre of gravity always stays above one foot or the other. This reduces the sideways forces and makes it much less likely that your foot will suddenly slip out from under you. LV



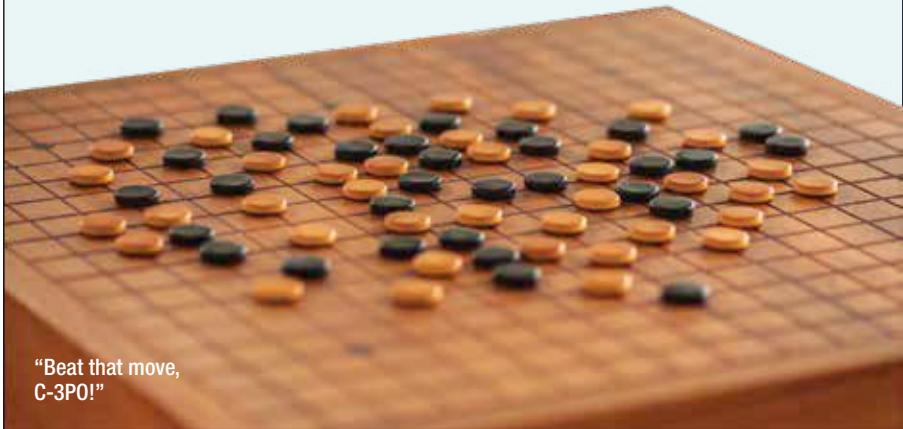
### KNOW SPOT

Twenty people, all over 1.52m tall, crammed into a Smart car in Los Angeles on 20 September 2011



## Are there any games at which people can still beat computers?

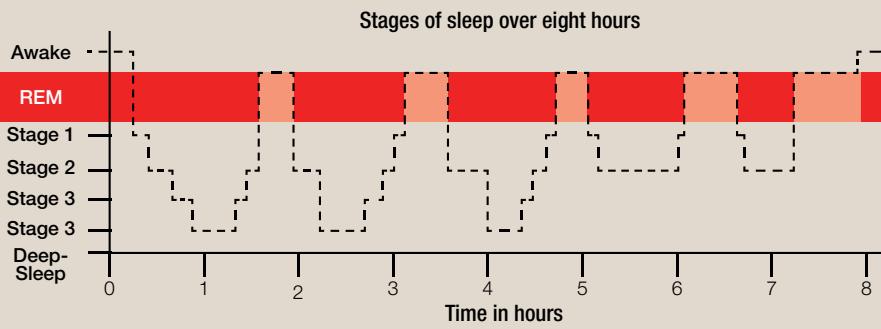
Humans still have the edge in the game of Go. Like chess, it’s played on a chequered board. But the board has more squares (19x19) and each piece can perform many more potential moves. While chess becomes more computationally straightforward as the game progresses and pieces are removed, Go requires more judgment and intuition. These attributes are more suitable to human intelligence than machine algorithms. GM



## Why do we toss and turn when we sleep?

A typical night’s sleep consists of REM and non-REM sleep. REM stands for Rapid Eye Movement and is named after the way your eyes dart around under your eyelids. REM sleep is when you dream. To prevent you acting out your dreams, nerve impulses from your motor cortex are intercepted in the spinal cord and blocked. So you’ll never thrash about during a dream, no matter how vivid it is. Instead, most

of the tossing and turning actually happens in the brief moments after REM sleep when you wake up. This only lasts a few seconds and we usually don’t remember having woken, so it feels like we are tossing and turning in our sleep. You can have four or five REM/non-REM cycles every night and the wakeful interludes give you a chance to change position or adjust the covers. LV



## VITAL STATS

316,600

People over 100 years old live around the world. By 2050, this figure could increase to more than three million

## Why does turning a device off and on often solve issues?



Many devices run some kind of computer code. The software often runs in a loop, executing commands repeatedly while the device awaits input. For instance, your screen constantly refreshes until you press a button. Sometimes, the code slips into a non-functional permanent loop that only breaks when you reset everything by switching the device off and on. GM

## How long do consoles spend in development?

Details on the latest consoles, the Xbox One and PS4, are shrouded in secrecy. But generally, it takes three to five years to develop a console. Sony's earlier machine, the PS3, launched in November 2006 after many delays. The first plans were drawn up as far back as 2000, when Sony teamed up with Toshiba and IBM to develop the console's bespoke Cell CPU. Microsoft is a bit faster – the Xbox 360 launched just before Christmas 2005 and began development about three years previously. GM



Sony's PS3 took around six years to develop

## Why does putting a finger down your throat make you vomit?

Nerves in the roof of your mouth, back of your tongue and throat trigger the pharyngeal or 'gag' reflex if they're touched by anything big enough. Young babies have a gag reflex sensitive enough to be set off by solid food to help protect them from substances that they aren't able to digest. Later, the gag reflex prevents choking but about one in three people don't seem to have a gag reflex at all. LV



"I really shouldn't have eaten that dodgy kebab"

## TOP TEN PHOBIAS



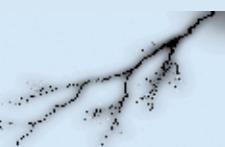
### 1. Arachnophobia

Fear of spiders  
Incidence: 33 per cent



### 2. Ophidiophobia

Fear of snakes  
Incidence: 33 per cent



### 3. Astraphobia

Fear of thunder/lightning  
Incidence: 15 per cent



### 4. Trypanophobia

Fear of needles  
Incidence: 10 per cent



### 5. Claustrophobia

Fear of enclosed spaces  
Incidence: 10 per cent



### 6. Odontophobia

Fear of dentists  
Incidence: 9 per cent



### 7. Aviophobia

Fear of flying  
Incidence: 7 per cent



### 8. Acrophobia

Fear of heights  
Incidence: 5 per cent



### 9. Cynophobia

Fear of dogs  
Incidence: 3 per cent



### 10. Agoraphobia

Fear of public spaces  
Incidence: 2 per cent

NATURE | SNAPSHOT

# SNAPSHOT





## Making waves

Sliding down this 30m-tall wall of water as it cascades towards Praia do Norte beach in Nazare, Portugal, is the tiny figure of Garrett McNamara, a thrill-seeking surfer famous for riding monstrous waves.

The colossal swells begin when storms arising in the North Atlantic during winter push vast quantities of water towards the European coast. The unique features of the Praia do Norte coastline then transform this mass of water into the spectacular breakers pictured here.

“A deep water canyon offshore of Nazare allows the wave to travel towards the coast without losing too much energy along the way,” explains Matthew Lewis from the School of Ocean Sciences at Bangor University.

“When a wave approaches the shoreline, the bottom of the wave starts to ‘feel’ the seabed, which slows its speed, resulting in energy loss. The headland also focuses the energy,” says Lewis.

“The wave starts to slow down as it reaches shallower water, which changes its direction and focuses the mass of water and energy together, resulting in very large waves.”



## Toxic beauty

In central Poland, coal ash leaks from the Belchatów power station through outlets into nearby clear waters, painting the surface with sinister grey veins. Belchatów is the largest coal-fuelled plant in Europe and emits more than 30 million tonnes of CO<sub>2</sub> every year, more than any other in the continent.

The shot was taken from a paraglider by Polish photographer Kacper Kowalski, as part of a project named 'toxic beauty' that features images of chemical plants, mines and landfill sites taken from a bird's-eye perspective.

"Coal-fired power generation comes with significant costs to the environment and human health," says Chukwunonye Ezeah, a researcher in waste and environmental management at the University of Wolverhampton. "Water run-off from coal washeries carries heavy metals that contaminate groundwater, rivers and lakes, affecting aquatic flora and fauna.

"Most importantly for human health," he adds, "the combustion of coal releases emissions of harmful gases such as sulphur dioxide, nitrogen oxides and carbon monoxide, and various trace metals like mercury, into the air through stacks that can disperse this pollution over large areas."





KNIGHTSCOPE



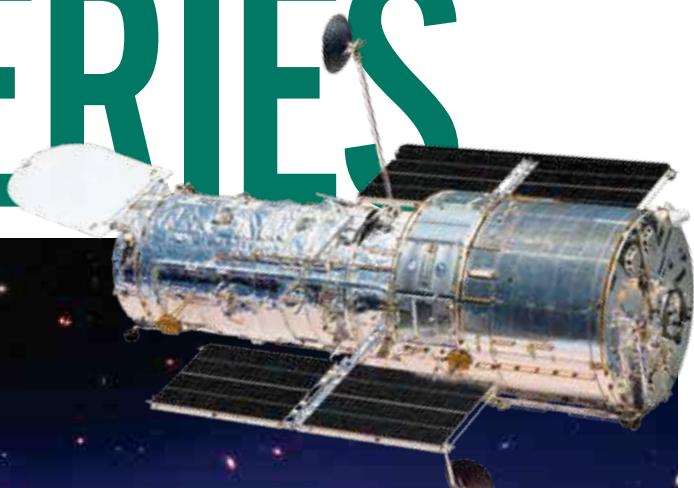
## Robotic arm of the law

This 1.5M-tall, 136kg robot seems a long way from the trigger-happy robocop of the movies. Yet according to its makers, Knightscope, the K5 autonomous data machine is the future of crime prevention. The robot has four cameras, giving it 360-degree views day and night, plus facial recognition software, and sensors that detect heat, radiation, and nasty biological or chemical agents.

When tests begin in earnest this year, it won't replace police or private security guards. Rather, it will help them by carrying out monotonous and dangerous tasks. "K5 can rove around outdoors 24/7, charging itself up when it needs to," says William Santana Li of Knightscope. "It can process 300 car licence plates a minute using optical character recognition." K5 looks innocuous, but it's no pushover. "There's a piercing, very painful alarm if you mess with it," warns Li.

# DISCOVERIES

## DARK MATTER MAY NOT BE SO **'DARK'**



Galaxy clusters are helping researchers to study dark matter

**D**ark matter makes up a whopping 85 per cent of matter in the Universe, but no one knows exactly what it is. It is called 'dark' because it is thought to interact only with gravity, making it invisible to telescopes. It can, however, be detected indirectly due to the distorting effect of its mass on the light from background galaxies, via a technique known as gravitational lensing.

Now, an international team of astronomers, led by researchers at Durham University, believes they might have observed the first signs of dark matter interacting with another kind of force.

It is currently thought that all of the Universe's galaxies exist inside clumps of dark matter. Without the constraining effect of dark matter's extra gravity, galaxies such as the Milky Way would fling themselves apart as they spin.

The research team used the Hubble Space Telescope to view the simultaneous collision of four distant galaxies at the centre of a cluster of galaxies 1.3 billion light-years away. They noticed one such clump of dark matter appeared to be lagging behind the galaxy it surrounds by 5,000 light-years. To put this in context, it would take NASA's Voyager craft 90 million years to travel that distance.

Computer simulations run by the researchers show that this lag can be explained if dark matter interacts, even very slightly, with forces other than gravity. The extra friction caused by such interactions would make the dark matter slow down, and eventually begin trailing behind its parent galaxy. Exactly what force this could be, however, is unclear.

"We used to think that dark matter sat around, minding its own business," explains lead author Dr Richard

Massey. "But if it slowed down during this collision, this could be the first dynamical evidence that dark matter notices the world around it. Dark matter may not be completely 'dark' after all."

There is more work to be done in determining exactly what is happening. Similar observations of more galaxies and further computer simulations of galaxy collisions are under way to confirm the interpretation and to investigate it further. And if the observations are confirmed, the work could lead to the emergence of new physics, the researchers say.

"Our observation suggests that dark matter might be able to interact with more forces than just gravity," says team member Prof Liliya Williams. "The parallel universe going on around us has just got interesting. The dark sector could contain rich physics and potentially complex behaviour."

## TIMELINE A history of dark matter

1947

Swiss astronomer Fritz Zwicky proposes dark matter's existence after noting a discrepancy between the mass of visible matter and the calculated mass of the Coma galaxy cluster.

2003

Cornell University's Vera Rubin notices that galaxies at the edge of the Universe move faster than expected. She suggests that dark matter could be causing this.



Physicist Mordehai Milgrom disagrees. He says the measured mass is correct, but Newtonian mechanics needs updating. He dubs the theory Modified Newtonian Dynamics.

2010

2014

LUX experiment begins in South Dakota. It aims to detect weakly interacting massive particles (WIMPs), a hypothetical particle candidate for dark matter.

## PATENTLY OBVIOUS

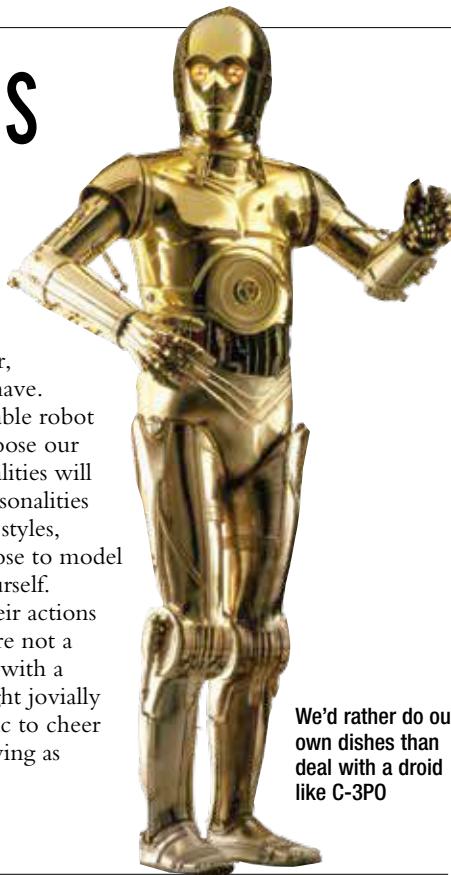
Inventions and discoveries that will change the world

### AFFABLE ANDROIDS

As the dawn of robot butlers comes ever closer, maybe it's time to think about how they'll behave. Google has revealed plans to create downloadable robot personalities, meaning that we'll be able to choose our perfect computerised companion. The personalities will be stored on a remote server, and different personalities will see the robots adopting different speaking styles, stances and facial movements. You might choose to model your robot on a celebrity, a friend or even yourself.

Google's robots will also be able to tailor their actions based on your mood. If the robot knows you're not a morning person, it might gently wake you up with a fresh coffee; if you're caught in a storm, it might jovially offer an umbrella and play some uplifting music to cheer you up. Let's just hope they're not all as annoying as C-3PO.

Patent number: US 8,996,429



We'd rather do our own dishes than deal with a droid like C-3PO

### DROWNING SOUND

If you've ever put out a fire, it's a good bet a fire extinguisher was involved, spraying messy, toxic chemicals everywhere.

Now, two US engineering students have invented a no-mess alternative that douses fires with sound. It's based on the simple principle that sound waves are pressure waves. When directed at a blaze, the waves separate burning material from the oxygen that's fuelling it, starving the fire. The effect only works at low frequencies, though, so you might need to get out that old Barry White album.

Patent pending

### WINDOWS OF WISDOM

You're flying over a city and you spot an unusual landmark below. Intrigued, you point at it through your cabin window, and a display pops up telling you what it is. This is the scenario dreamt up by Airbus in a recent patent application. Their interactive, touchscreen window will detect where you're pointing at and offer up information about it onscreen. You'll be able to swot up on your destination, learn about the landscape below or even identify constellations in the night sky.

Patent publication number:  
US 20150077337

## GOOD MONTH/ BAD MONTH

### IT'S BEEN GOOD FOR: FAST FOOD LOVERS



Usain Bolt confessed to eating 1,000 chicken nuggets throughout the Beijing Olympics. But he might be on to something. Small amounts of fast food can be just as effective as sports supplements in restoring muscle energy stores after a workout, according to a study at the University of Montana.

### ARTSY TYPES

If you enjoy painting or sewing, you may be helping your memory. In a study carried out by the Mayo Clinic, those who engaged in arts in both middle and old age were 73 per cent less likely to develop mild cognitive impairment than those who did not.

### IT'S BEEN BAD FOR: SHORT PEOPLE



As well as being denied rollercoaster rides, it seems short people are also more at risk of heart disease. A team at the University of Leicester analysed genetic data from 200,000 people. They found that for every 6.35cm (2.5 inches) difference in height, the risk of coronary heart disease increases by 13.5 per cent. Compared to a 168cm (5ft 6in) person, a 152cm (5ft) person has a 32 per cent higher risk, on average. The exact reasons still remain unexplained.

### NIGHT OWLS

Rise and Shine! Night owls are more likely to develop diabetes and degenerative muscle loss than early risers, even when they get the same amount of sleep, Korean researchers have found. The effect could be due to unhealthy behaviour or poorer sleep quality.

# 10 DISCOVERIES THAT WILL SHAPE THE FUTURE



The screen for your next tablet computer may be made of DNA. Researchers at Tel Aviv University have created a naturally fluorescent material capable of emitting a full range of colours in a single flexible pixel layer, as

opposed to the several rigid layers that make up today's screens. It could be used in flexible displays that can be rolled up when not in use. The material is made from peptides and DNA – two of the most basic building blocks of life.

## 8 Battery that charges in one minute

Fed up of your phone running out of juice? Well, help may be on the way in the form of an aluminium-ion battery developed at Stanford University that could replace lithium-ion technology in powering everything from smartphones to laptops. The device generates 2V of electricity, about half of current lithium

technologies, but it is flexible, durable and can fully charge a device in just 60 seconds.



The first aluminium-ion battery is safe and flexible

## 7 Non-slip shoes

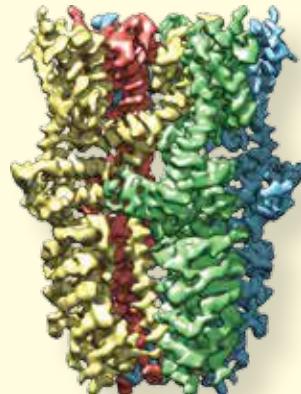
Get a grip! A material that may help pedestrians stay on their feet in icy conditions has been created by Canadian researchers. Made from glass fibres embedded in rubber, the material acts the same as regular rubber on dry surfaces but provides significantly better traction on ice.



Tiny glass fibres act like minuscule studs to grip slippery ice

## 9 New class of painkiller

If you're a fan of the spicy green condiment used in sushi, chances are you've been giving your 'wasabi receptor' a thorough workout. TRPA1 is a protein located in nerve cells and is triggered by wasabi, garlic and even tear gas. Now, by mapping the protein's atomic structure, a team at the University of California has found it is also involved in transmitting several types of pain signal. The finding could lead to the development of a new class of painkillers, they say.



TRPA1 receptors are comprised of four parts and are located in nerve cells

## 6 Lab-grown lungs

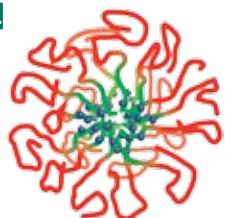
Breathe easy. Scientists at the University of Michigan have used stem cells to grow self-organising mini lungs, complete with the bronchi and alveoli that are found in the human organs. Though the lung structures lack blood vessels, they represent an important step in moving away from animal testing to more effective drug trialling and medical research, the team says.



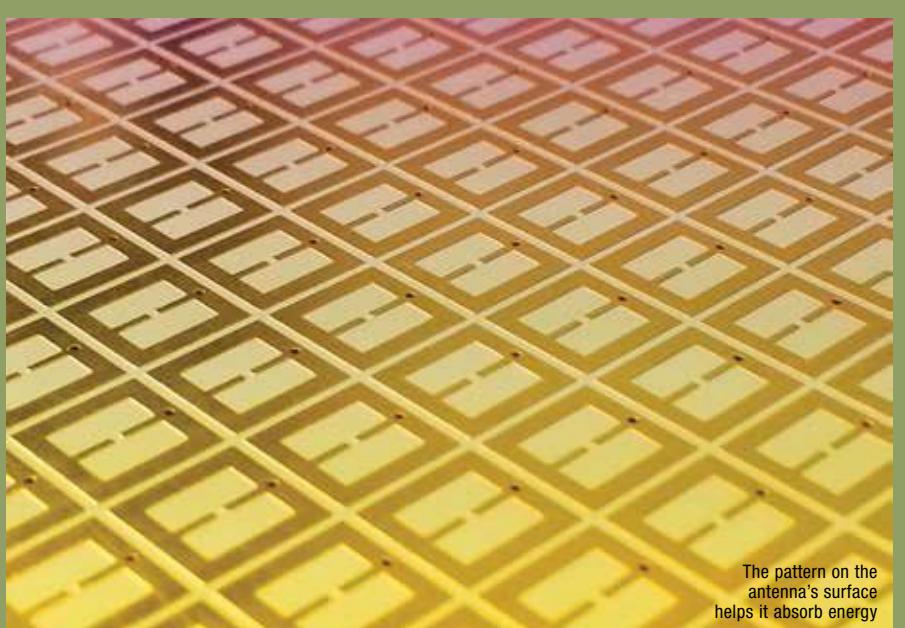
## 5

### Nanotech gnashers

Nanotechnology may soon save you from a trip to the dreaded dentist's chair. Researchers at Queen Mary University have developed tiny spherical particles that transport a payload of antibacterial drugs to the surface of the teeth to fight plaque and tooth decay. **The particles could be put into toothpastes and mouthwashes or used to combat other plaque-like substances, known as biofilms, such as those that form on orthopaedic implants.**



The nanoparticles cling to the tooth surface and are not washed away by saliva



The pattern on the antenna's surface helps it absorb energy

## 4

### Plastics from eggs

Yes, they taste great with bacon, but **eggs could now be used for making antibacterial plastics.** Scientists at the University of Georgia made the material by blending albumin, a protein found in eggs, with glycerol, a traditional plasticiser.

## 3

### Energy-harvesting surface

Every day, the Earth is bombarded with electromagnetic radiation. Now, team at the University of Waterloo has created a 'metasurface' antenna that can potentially harvest this energy and make it useful. It is much better at capturing energy than

traditional designs. **The antenna could be sent into space to collect energy and beam it back to Earth. The surface has a special pattern engraved into it that can be tuned to absorb specific frequencies of radiation.**

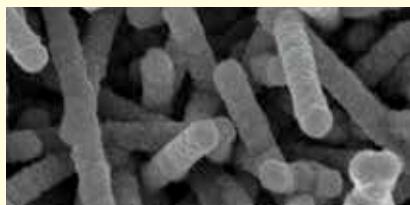
## 2

### Viruses heat up water



A tobacco leaf with the characteristic patterning caused by the mosaic virus

Viruses can give us humans a burning fever, but now a team at Drexel University has found a way of using viruses to make water boil three times more quickly. The technique works by covering a heating element with a virus found in tobacco plants. The coating decreases the size and number of bubbles that form around the element, which in turn increases the heat transfer to the liquid. **The technique could be used in everything from power stations to cooling systems for electronic devices.**



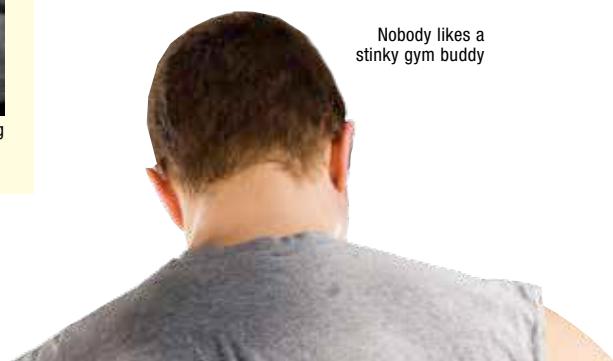
The nanostructure of the virus-based coating is helping researchers to understand and improve heat transfer

## 1

### BO bacteria identified

As anybody unfortunate enough to spend time in a packed gym changing room can attest, body odour is bad news. Now, researchers from the University of York have discovered that enzymes in the bacterium *Staphylococcus hominis* are the guilty party. They break sweat down into thioalcohols, the smelly compounds found in armpit aroma. **The findings could lead to deodorants that specifically target this particular bacterium, leaving us smelling sweeter for longer.**

Nobody likes a stinky gym buddy



# 1 MINUTE EXPERT

## The IPK



### WHAT'S THAT?

Since 1889, the mass of a kilo has been defined as that of an object known as the International Prototype Kilogram (IPK). It is made from 90 per cent platinum and 10 per cent iridium and is kept in a pair of bell jars under lock and key in Sévres, Paris.



### SO IT'S LIKE THE DADDY OF ALL KILOGRAMMES?

Right. The problem is that it's slowly losing mass. Over the last century it has shed 100 micrograms.



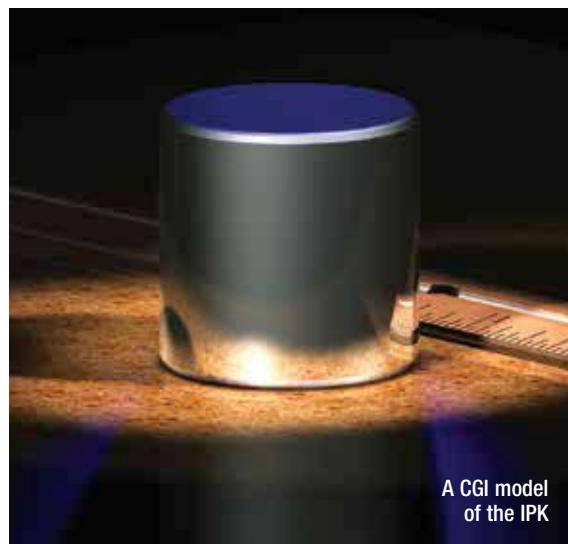
### THAT DOESN'T SOUND LIKE MUCH. WHAT'S THE PROBLEM?

It may not make any difference if you're making a Victoria sponge, but when it comes to sensitive experiments, scientists demand as much precision as they can get.



### I GUESS. SO WHAT'S THE SOLUTION?

A group at the German National Metrology Institute has come up with a method that involves growing a silicon crystal. A silicon atom has a mass of 28 atomic mass units, and silicon has a very regular structure, so by growing a silicon crystal with  $2.15 \times 10^{25}$  atoms, they can produce the most accurate physical kilogram so far. They hope to produce the crystal by 2018, to an accuracy of one in 100 million atoms.



# WEB CLICKS

## New websites, blogs and podcasts

### SUBMARINE CABLE MAP

[Submarine-cable-map-2015.telegeography.com](http://Submarine-cable-map-2015.telegeography.com)



When you're using the internet, you don't often think about the mechanics of it. This site encourages you to do just that, showing you the network of cables on the seabed, which make transoceanic communication possible. It resembles an antique map stylistically, but is fully clickable and zoomable – and strangely fascinating.

### ZOMBIE TOWN

[Http://mattbierbaum.github.io/zombies-usa/](http://mattbierbaum.github.io/zombies-usa/)



Scientists have made a disease dynamics simulator to model how a zombie infection outbreak would spread across the US, and you can play with it here! Click on the map to start an outbreak, then sit back and watch it wreak havoc. It may sound fantastical and frivolous, but this kind of model can be used for real diseases, too.

### MORE THAN SCIENTISTS

[Morethanscientists.org](http://Morethanscientists.org)



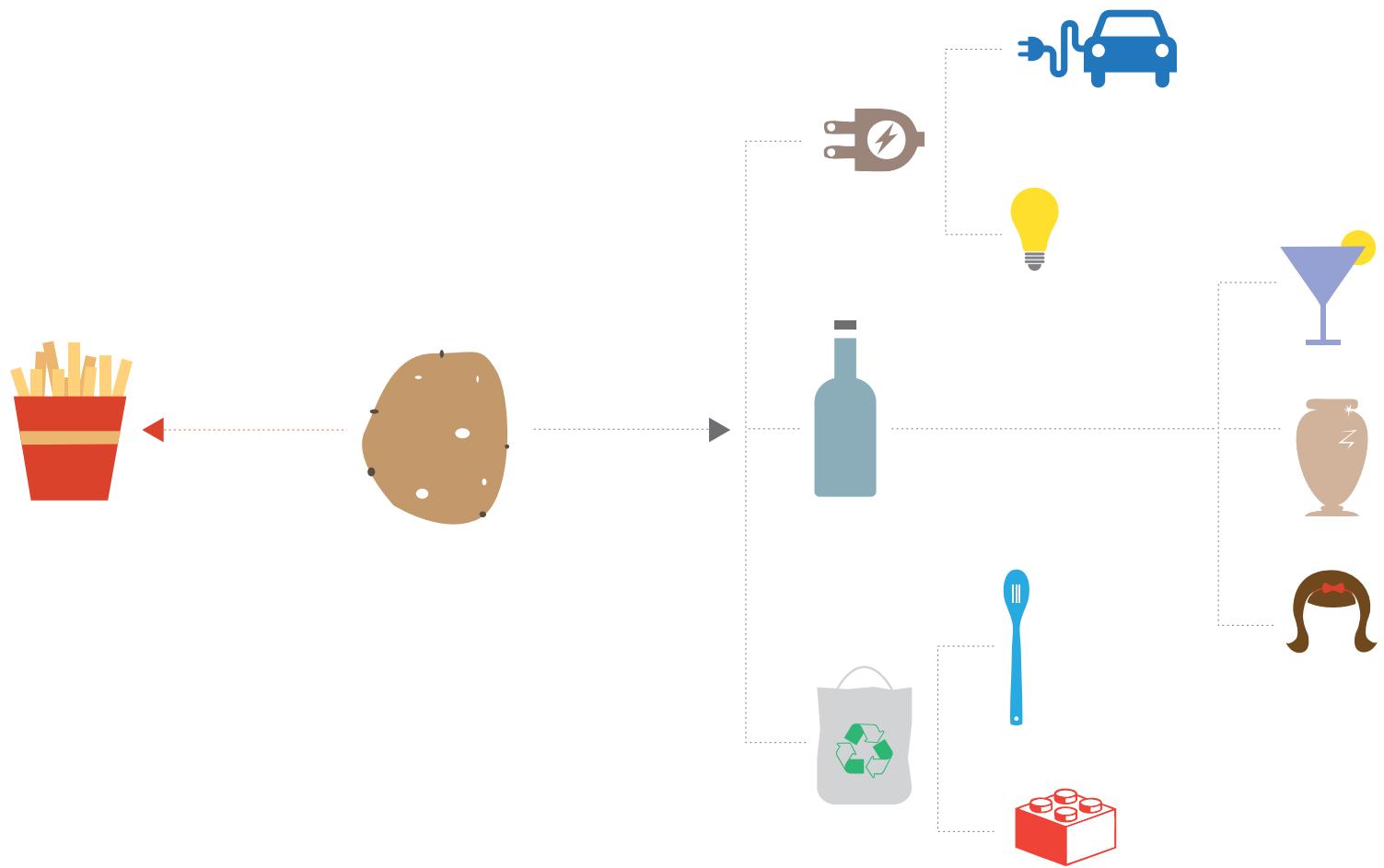
If you're sick of hearing about the 'debate' on climate change and just want to know what actual scientists think about it all, visit this website. Scientists from a diverse selection of disciplines and backgrounds step out from behind their laboratory benches and use videos to share their stories about what climate change means to them.

### MIKULSKI ARCHIVE FOR SPACE TELESCOPES

[Mast.stsci.edu](http://Mast.stsci.edu)

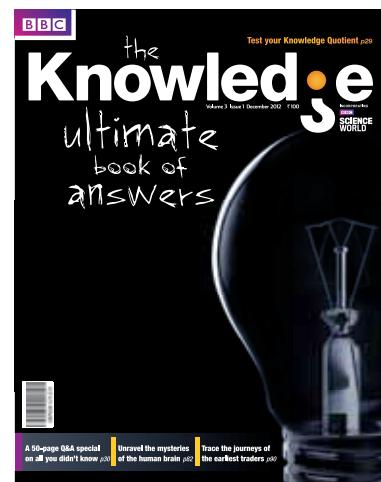


Hubble has been exploring the Universe for over 25 years and has amassed a whole load of data – and you can find it all here. If you're looking for a handpicked gallery of gorgeous space photos, you're in the wrong place. But if you want to dig into the actual source material, start with the example searches on this site. Soon you'll be exploring Hubble images like a pro.



THERE'S MORE TO EVERYTHING.  
EVEN POTATOES.

KNOW YOUR STUFF.





# DEADLY MIE ERU

# GAS EXPLOSION

This year marks 200 years since Tambora exploded, searing into history as the most powerful volcanic eruption since records began. **Bill McGuire** asks if it could happen again...

The temperature is stifling, sucking the sweat from your body. Everything is utterly black. It is impossible to see your hand in front of your face. Worst of all is the blizzard of ash, falling so quickly that it clogs every orifice. You try desperately to suck in the scorching air, but the slimy concoction of ash and saliva that fouls your mouth and throat acts as a barrier. You are suffocating. It gets even hotter. A wave of blistering heat assaults

your body, crisping your skin and bringing unimaginable agony. Your last act is to open your mouth to scream, but no sound emerges. Instead, you inhale super-heated gas that shreds your windpipe and destroys your lungs.

Death by volcano is not pleasant, as 12,000 inhabitants of the Indonesian island of Sumbawa discovered exactly 200 years ago. In April 1815, the island's Tambora volcano tore

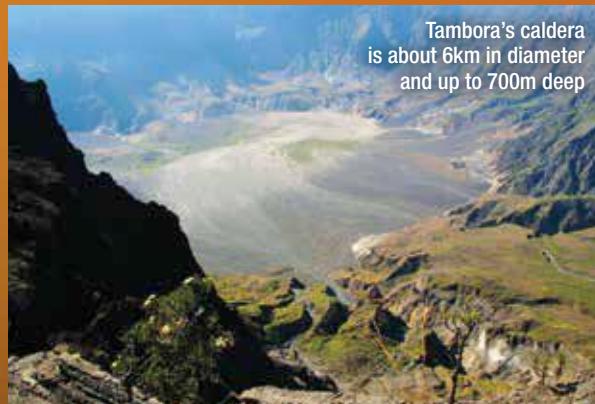
itself apart in the largest known eruption of the historical period, and one of the biggest since the Ice Age. But what happened in the weeks and months following the eruption, and will we ever be threatened by such an event in the future?

In many ways, those that succumbed to the deluge of ash and the tempests of boiling gases were the lucky ones. During the months that followed, five times as many people lost their lives ►

on Sumbawa and neighbouring islands to the combined onslaught of famine and disease. And the lethal consequences did not end there; the huge volume of sulphur gases injected into the stratosphere caused climate mayhem half a world away.

As Tambora is secreted away on an obscure island in the Indonesian archipelago, the eruption might have gone unnoticed in Europe had it not been for a combination of fortuitous political circumstances. Having ousted the incumbent Dutch forces from the island of Java in 1811, a certain Thomas Stamford (later Sir Stamford) Bingley Raffles was installed by the British as Lieutenant Governor of the island. Famed today for establishing the city-state of Singapore and for the iconic hotel there that bears his name, Raffles also has the gratitude of today's volcanologists for the contemporary written accounts he provided of the Tambora blast.

As one of 78 active volcanoes in the world's most volcanically lively region, Tambora must have been a pretty impressive peak, with an estimated height of up to



Tambora's caldera is about 6km in diameter and up to 700m deep

4,300m. It had erupted just once in the previous five millennia, which undoubtedly convinced the local inhabitants that the volcano was long-extinct and presented no threat. It is possible that they did not even know the mountain was a volcano.

The first evidence that this optimistic assessment was way off the mark came in the spring of 1812, when the first rumblings

## TIMELINE How it Happened

### 1812

The first rumblings of the Tambora volcano for more than 1,000 years are followed by small detonations of steam and ash. Locals start to worry.

### 5 April 1815

The first major explosion lasts for two hours and sends ash to a height of 33km. The loud booms are misinterpreted in Java as cannon fire.

### 10 April 1815

A second blast launches the climactic phase of the eruption, which removes the top 500m or so of the volcano. Pyroclastic flows annihilate communities.

### July 1815

The explosions end, leaving behind a 6km-wide caldera. About 12,000 are dead and a blasted landscape is buried beneath huge amounts of ash.

### Months after

The destruction of crops and the burial of agricultural land brings famine that takes an estimated 60,000 lives on Sumbawa and neighbouring islands.

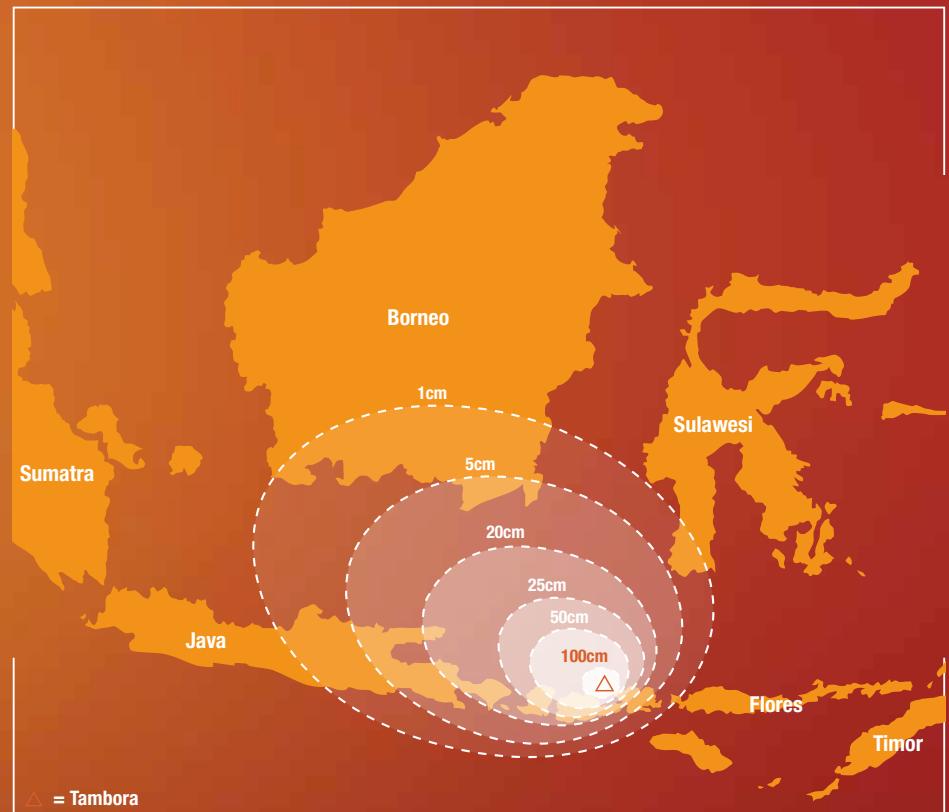
### Summer 1816

Unseasonably bitter weather wrecks harvests across the eastern United States and Europe. This brings bread riots, famine and disease.



Left: Tambora measures about 60km in diameter at sea level, forming the Sanggar peninsula

Right: Depth of ash that fell on Sumbawa and neighbouring islands when Tambora erupted



Skeletal human remains excavated from a buried Sumbawa village

began to make the local population nervous. Minor steam and ash explosions followed, but it was three years until things really started to get serious. The first titanic explosion occurred on 5 April 1815, the sound of which Raffles reports as carrying across to Java, where it spawned rumours of fighting and invasion. Following a short respite, a second colossal explosion five days later heralded the start of the climactic phase of the eruption, which seems to have lasted for three or four days. A gigantic, 45km-high column of ash reached to the edge of space, while hurricane blasts of scalding gas and hot ash scoured the surrounding land of all life. A powerful tsunami, spawned by the huge volumes of ash and debris flowing into the sea, buffeted the neighbouring coasts. When the ash-laden skies cleared weeks later, it was to reveal a decapitated volcano; its towering peak replaced by a

hole measuring 6km across. The next few months were a living hell for survivors, whose homes and crops were buried beneath thick layers of ash. Disease and starvation were rampant, eventually taking the lives of an estimated 60,000 men, women and children.

#### Blast furnace

In total, the eruption blasted out a staggering 50 cubic kilometres of ash and debris – around five times that ejected by the more famous Krakatoa eruption, nearly seven decades later.

More than 20cm of ash fell in eastern Java, while even in Borneo, 500km to the north, ash was 5cm deep. Enormous rafts of pumice, some an astonishing 5km long, clogged the surrounding ocean, hindering shipping in the region for three years after the eruption. The detonations during the climactic phase were felt over an even wider area, shaking buildings ►

across Java and heard as far away as Trumon in north Sumatra, 2,600km from the volcano.

While the statistics of the Tambora eruption are impressive, the event is best known for its wide-ranging impact on the climate. The enormous volumes of ash settled out of the atmosphere in a matter of weeks. The 200 million tonnes of tiny sulphate particles, injected into the stratosphere, however, hung around for much longer, forming a so-called aerosol veil across the planet.

### The big chill

This veil proved very effective at blocking incoming sunlight, causing temperatures to plunge and inflicting an unseasonable chill upon the northern hemisphere. Earmarked in the historical record as 'the year without a summer', 1816 saw snow in New York state in June and unprecedented summer frosts wiping out crops across the eastern states. In Europe, the summer was the second coldest of the past six centuries, bringing widespread crop failures. The bread riots, starvation and disease that followed have been described as marking the last great subsistence crisis in the western world, taking – in Ireland alone – as many as 44,000 lives. Tambora's remote legacy also had some surprising cultural consequences that remain with us today. The brilliant, sulphurous sunsets that followed the eruption have been held up by some as providing inspiration for the increasingly flamboyant skies of some of JMW Turner's post-1814 works. Similarly, the weather of 1816 is charged with supplying the brooding backdrop that – during a 'wet and ungenial' summer spent



Eyjafjallajökull in Iceland caused chaos to European flights when it erupted in 2010



JMW Turner's paintings, such as Chichester Canal, celebrate the orange-tinged sunsets that were seen following Tambora's eruption



A coil of rope lies within the remains of a collapsed building on the island of Sumbawa

at the Villa Diodati on Lake Geneva – inspired Mary Shelley to write *Frankenstein* and prompted Lord Byron to compose his poem, *Darkness*.

Now, 200 years on, we await the next Tambora with some trepidation. Volcanic blasts on this scale seem to happen, on average, a few times every millennium. The probability of another one coming along in the next 50 years is maybe 10 per cent, or even higher. Based on the three-year escalation of activity that preceded Tambora's climactic explosion, it may be that we will have a decent lead-in

time before the next great volcanic blast, giving us the opportunity to plan for the event. The problem is that we are still not able to determine if increasing restlessness at a candidate volcano will end in an Earth-shattering eruption or a return to slumber. With a number of potential future Tamboras already bubbling and swelling in various regions, the stage may be set for the next 'big one'.

So, given what we now know about massive eruptions and the potentially disastrous impact they can have on the climate,

# THE NEXT TAMBORA?

Volcanologists can pinpoint when an eruption will take place, but many volcanoes remain unmonitored

When provided with a half-decent geophysical monitoring network, volcanologists are pretty good at predicting when an eruption might occur a week or two before it takes place. Pinpointing in advance the next Tambora is a different kettle of fish, especially given that there are at least 1,300 active volcanoes around the world, only a fraction of which are currently monitored. We can, however, try and narrow the odds a little. Bearing in mind that half of the 20 biggest eruptions since 1800

occurred at volcanoes that – like Tambora – had not erupted in historic records, we should perhaps focus on those seemingly innocuous volcanoes that have been quiet for millennia, especially those that are showing signs of life. Restless Mount Paektu on the border between North Korea and China immediately springs to mind, along with steadily swelling Uturuncu in southwestern Bolivia and the rapidly inflating Laguna del Maule volcano in Chile.



An infrared view of Tambora, taken from space

**"The weather of 1816 supplied the brooding backdrop that inspired Mary Shelley to write *Frankenstein*"**

will we be ready? Sadly, it would come as no surprise if we were caught out. After all, we were completely unprepared for the relatively minor eruption of Iceland's Eyjafjallajökull in 2010, which played havoc with air

travel across Europe, even though it was only a little over half a century since Icelandic ash last invaded European airspace. Clearly, when it comes to the impact of volcanic eruptions, we have very short memories. Before it's too late, let's hope that we don't forget the important lessons Tambora has taught us about the devastating and far-reaching consequences a single volcanic blast can have for our world. ☐

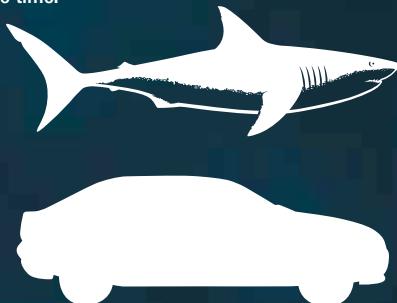
Bill McGuire is Professor Emeritus of Geophysical and Climate Hazards at UCL. His current book is *Waking The Giant*.

# YOU'RE GONNA NEED A BIGGER BOAT

**It's 40 years since *Jaws* warned us not to go in the water. It's about time we got our teeth into the science behind this stunning predator, says Ken Wu**

## SIZE AND WEIGHT

The average length of adult great whites is between 3.7 and 4.9m, yet some truly enormous specimens have been reported. An example is one that was caught near Cojima, Cuba in 1945 measuring 6.4m. This shark allegedly tipped the scales at 3.3 tonnes, whereas adults normally weigh around 1.9 tonnes. However, the size and weight of this huge shark cannot be confirmed as accurate measurements were not taken at the time.



A great white is a similar length to a Ford Focus

The shark can accurately control its fins to maximise its efficiency in the water

## REPRODUCTION

Reproductive habits are mysterious in the great white, and no female has ever been seen giving birth. The mother develops the eggs in her **uterus**, which then hatch out inside her. The **embryos** get nutrition from a yolk sac and may even eat unfertilised eggs. Scientists think that the pups are born after 14–18 months gestation and measure between 1.1m and 1.65m. We cannot be certain when they reach sexual maturity, but it may be up to 26 years for males and 33 years for females. Youngsters predominantly prey on fish and then later expand their palate to include marine mammals.

## SPEED

The animal cruises at 8km/h (5mph), but can attain a top speed of 50km/h (31mph) for short bursts when chasing prey. It has a light, cartilaginous skeleton instead of bone, which makes it flexible and capable of executing rapid turns. The great white belongs to a group called the lamnid sharks; unlike most other fish, these can keep their bodies warmer than the surrounding water, allowing them to swim faster and for longer.

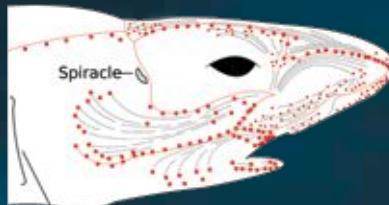
Shark skin is covered with tiny, tooth-like scales called dermal denticles that help reduce drag

Embryos

Uterus

## SIXTH SENSE

Like all sharks, the great white has a sixth sense that humans lack: electroreception. Special pores around the snout, eyes and lower jaw contain electrically conductive cells called the ampullae of Lorenzini, allowing the shark to detect tiny amounts of electrical activity generated by the muscle cells of potential prey. These nifty pores may even help the sharks to navigate using the Earth's magnetic field.



The ampullae of Lorenzini detect electrical activity

## LIVER

The shark's largest organ is the **liver** making up 28 per cent of its body weight. It contains large stores of fat and oils, which provide it with buoyancy since it lacks the gas-filled swim bladder that many other fish have. The liver also fuels its long migrations that can cover over 4,000km (2,500 miles).



A human liver is  
**300**  
times lighter than a great white shark's

Ovary

Stomach

Liver

## DIET

The great white typically feeds on seals and sea lions. It attacks in a rapid movement from below and behind, causing massive trauma. It then retreats to a safe distance; once the seal is dead, the shark returns to feed. The high fat content of these animals provides a good source of energy for the shark. But great whites will scavenge too, and have been seen chowing down on the carcasses of whales.



**2,187**

tins of tuna weigh the same as a male sea lion – a tasty meal for a great white

## SMELL

The great white possesses the largest **olfactory bulb** of any known shark species, with 18 per cent of its brain dedicated to processing and analysing smells. This enables it to detect one drop of blood in 10 billion drops of water. As well as finding food, their sense of smell helps great white sharks to detect and source pheromones. These chemicals are emitted by other great whites and are crucial for attracting potential mates.

To make up for a lack of eyelids, the great white has the ability to roll its eyes backwards to protect them when attacking prey or approaching unknown objects

Olfactory bulb

There are about 300 teeth in a great white's mouth. They often fall out and are frequently replaced, with only the front few rows being functional

## BITE

The highest bite force in the animal kingdom belongs to the great white, and is equivalent to at least 1.8 tonnes. They can maintain this force regardless of how wide their jaws are open due to a unique arrangement of muscles. They are unable to use these jaws to their full effect until they have developed enough 'mineralised cartilage', which most great whites don't achieve until they are three metres in length.

**3**



times more bite force is exerted by a great white than an African lion



Dani wears a soapy glove that enables him to hold a bubble without bursting it. The bubble is coloured with a pigment that fluoresces under UV light, emitted by his futuristic suit

# DON'T TRY THIS AT HOME!

You may have seen a live science demonstration before, but the work of this Spanish physicist is something else. Prepare to be amazed as his tricks of the trade are revealed by **Hayley Birch**

PHOTOGRAPHY BY ALBERT CHUST/ CREACIENCIA.ES



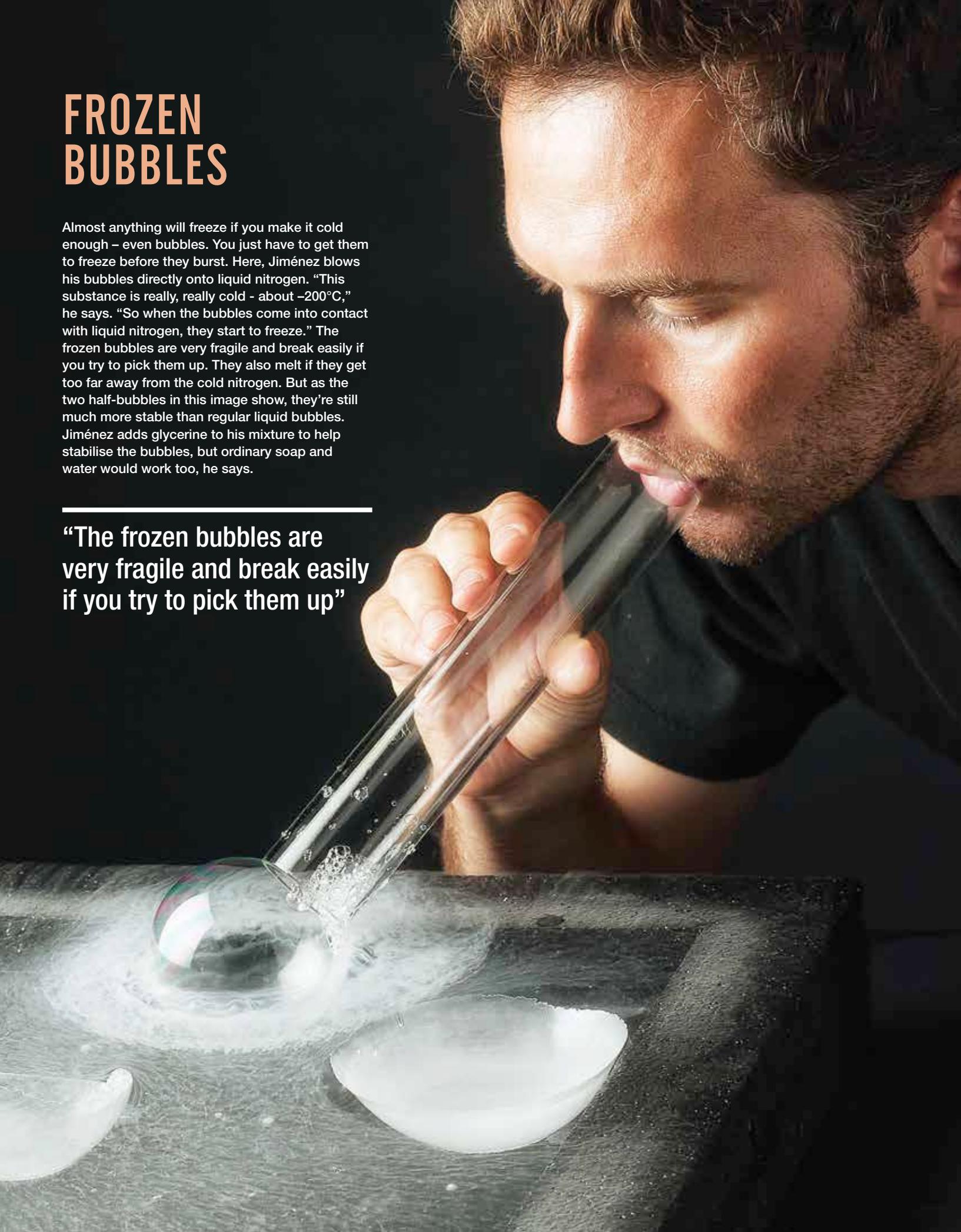
**B**arcelona-based physicist Dani Jiménez has been surprising live and television audiences with his visually stunning experiments. From freezing bubbles to lighting a fire that burns underwater, many prompt the question 'How did he do that?', as if there were some trick or illusion. But the photos prove there's no sleight of hand. And while a magician never reveals his secrets, a physicist... well, a physicist can be persuaded.

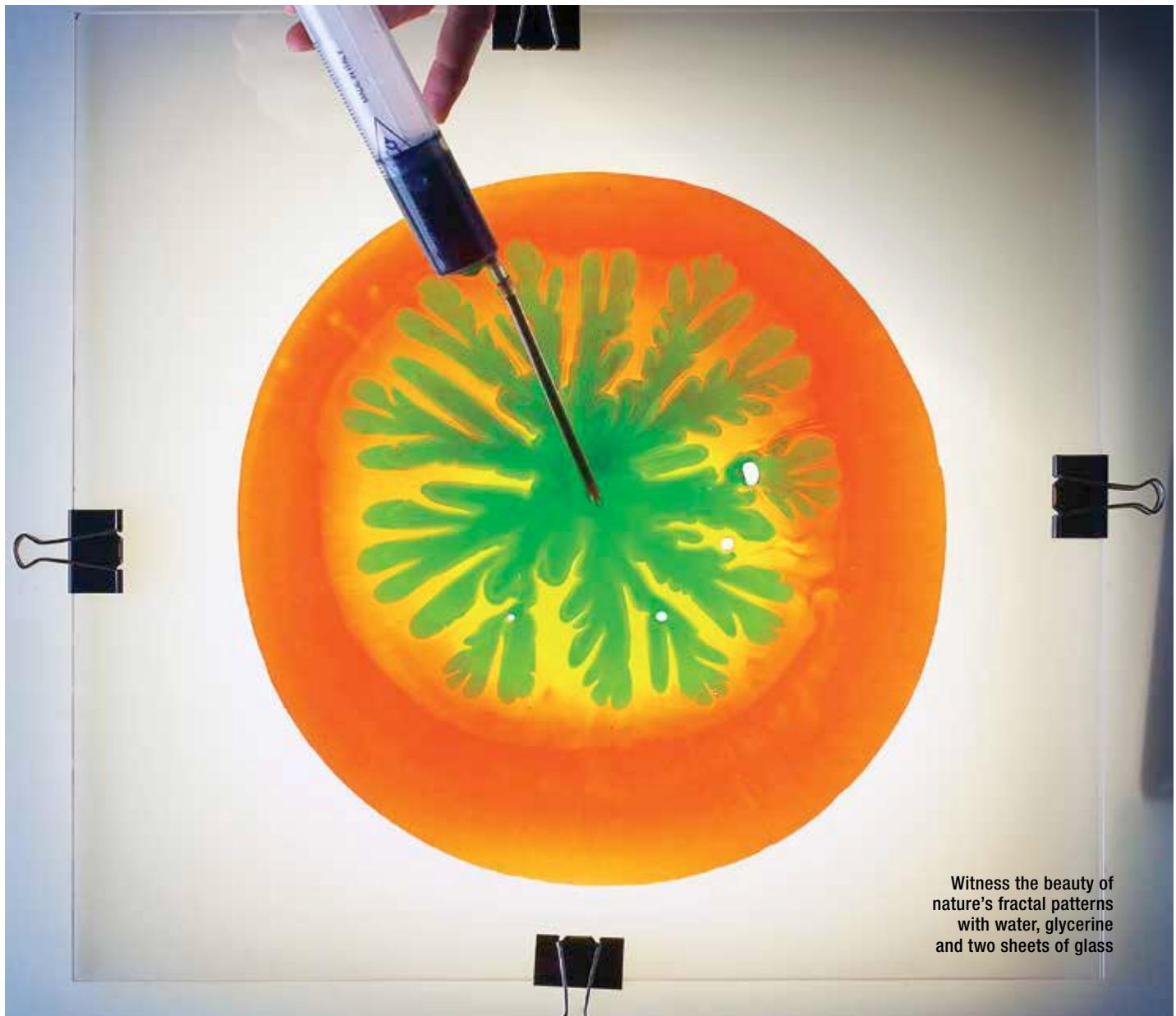
# FROZEN BUBBLES

Almost anything will freeze if you make it cold enough – even bubbles. You just have to get them to freeze before they burst. Here, Jiménez blows his bubbles directly onto liquid nitrogen. “This substance is really, really cold – about -200°C,” he says. “So when the bubbles come into contact with liquid nitrogen, they start to freeze.” The frozen bubbles are very fragile and break easily if you try to pick them up. They also melt if they get too far away from the cold nitrogen. But as the two half-bubbles in this image show, they’re still much more stable than regular liquid bubbles. Jiménez adds glycerine to his mixture to help stabilise the bubbles, but ordinary soap and water would work too, he says.

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**“The frozen bubbles are very fragile and break easily if you try to pick them up”**





## NATURAL FRACTALS

Shaped like a sprig of parsley, the green pattern at the centre of this image is made by squirting water into a thin layer of glycerine sandwiched between two sheets of glass. The liquids are mixed with food dyes to help make things easier to see. But although the pattern is pretty, it's not

immediately obvious what's so fascinating about it. It is, however, a fractal. This means it's repeated at different scales, so if you zoomed in, you would see a similar pattern at a closer magnification. The repeating shapes of fractals are found all over the place in nature, from snowflakes to Romanesco broccoli to pineapples.

Jiménez uses a syringe attached to a fine tube to squirt the green-dyed water into the glycerine through a tiny hole in the glass plate.

"We just pull the syringe and the water gets into the glycerine and creates the fractal," he says. "It's really important that

there's no air inside." The set-up relies on there being an extremely small gap between the two plates. It's known as a Hele-Shaw cell, invented by the English engineer Henry Selby Hele-Shaw – also, incidentally, the inventor of an early car clutch – for studying the flow of fluids to solve problems in mechanics. In the 1980s, physicists used Hele-Shaw cells to push water through a more viscous fluid, like glycerine. They found that it formed branched, fractal patterns that they called 'viscous fingers', something that was used to understand the behaviour of oil around oil wells.

It's not what you'd typically see on a clothes line, but with a bit of trickery you can reveal the plastic structure of a can; hydrochloric acid reacts with the can's aluminium, leaving plastic behind



**"Dip an aluminium can in hydrochloric acid and the acid attacks the aluminium, leaving only the plastic coating"**

## UNDRESSING A CAN

Acid eats metal - that's the essence of this can-stripping demonstration. Dip an aluminium can in hydrochloric acid and the acid attacks the aluminium, leaving behind only the plastic coating of the can. In the image above, the shapes of the cans – though a little crushed – are still recognisable, but according to Jiménez, it's not that easy to get good results. "This experiment is difficult because the plastic is really soft and breakable, so you have to be careful when you handle it," he says. "Some of the cans broke when we took the photos."



For perfect results, sand off the printing on the can first to let the acid get to the aluminium



A selection of tools (left) are needed for this task as you don't want your hands anywhere near the hydrochloric acid (right) that does the job of dissolving the aluminium





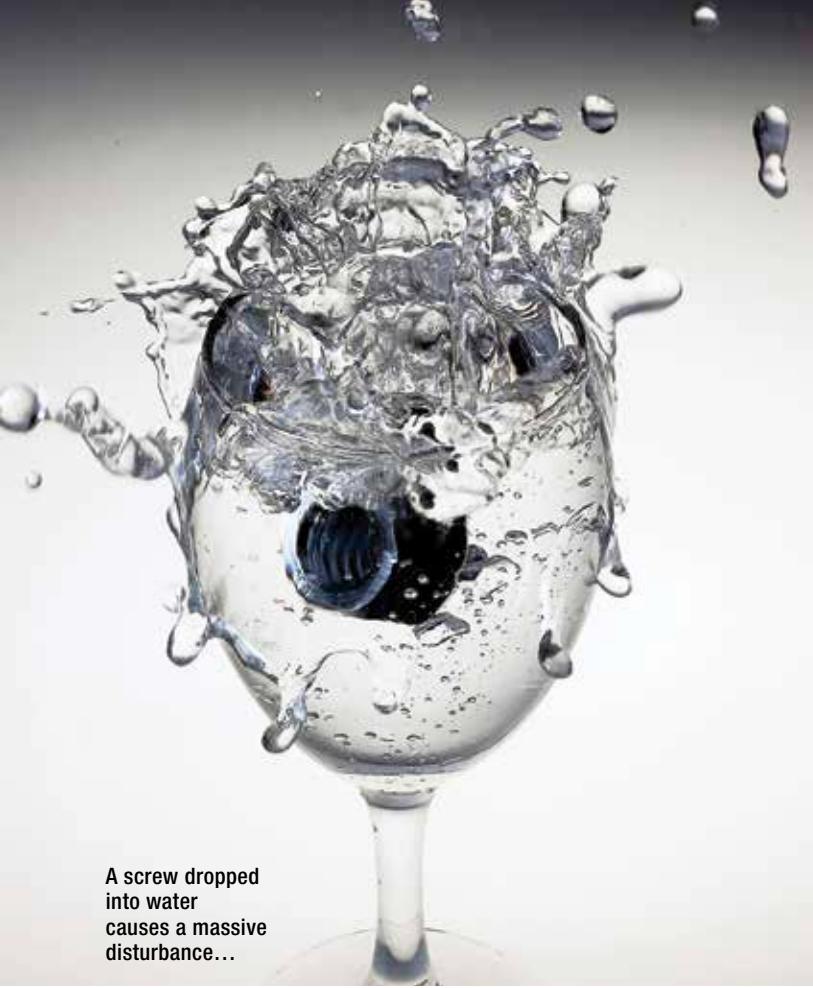
## UNDERWATER FIRE

This demonstration may look impressive, but somewhat counter-intuitively there's nothing particularly difficult about getting fire to burn underwater. It just needs a little help. If you can get your hands on some standard sparklers, you can try it out.

Fire needs oxygen to burn, which it usually gets from the oxygen ( $O_2$ )

molecules in the air. There's oxygen in water too, but it isn't available because it's locked up in the water ( $H_2O$ ) molecules. However, sparklers contain oxidisers – chemicals like potassium nitrate ( $KNO_3$ ) that provide extra oxygen. Just taping some sparklers together, lighting them and dunking them in a glass of water creates under-

water fire, although, says Jiménez, it burns a little less brightly than in the air. However, the tricky bit is photographing it. "We used a long exposure," he explains. "It's really important here to be in absolute darkness, so the sparkler's light is the only light when you capture the image. In these conditions you can capture the complete movement."



A screw dropped into water causes a massive disturbance...



...while oil holds its shape better, but still creates a classic splash. Below, glucose is so viscous that it simply displaces out of the glass

## BIG SPLASH, LITTLE SPLASH

Each of these glasses contains the same amount of three different liquids – clockwise from top: water, oil and glucose. But when the same object – here, a big bolt – is dropped into each glass, it creates a splash that looks remarkably different when captured on camera. This is all down to the viscosity of the different fluids, or how ‘thick’ they are.

The water is not very viscous, but the oil is a bit more so and the glucose is so thick that it barely leaves the glass when the screw is dropped in it. The same experiment gives slightly different results if you heat the liquids. “Oil and glucose would be a little less viscous if you warmed them up,” Jiménez explains. So you’d see a slightly bigger splash. Water, on the other hand, is fairly resistant to rising temperatures, so its splatter would be barely altered. This resistance to change is unusual among chemicals in nature and important. It means that organisms that live in, or depend on it, are to some extent protected from changing conditions. ☐



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Hayley Birch is a science writer and author of *The Big Questions In Science*.



ILLUSTRATOR: ANDY POTTS, PRESS ASSOCIATION

# HOW WE'LL BUILD A REAL JURASSIC WORLD

With the latest in the *Jurassic Park* series hitting the cinemas, **Brian Clegg** finds out if we really could bring extinct animals back from the dead...





# HOW TO BRING BACK EXTINCT CREATURES

Dinosaurs have captured our imaginations for decades, but recreating them is a formidable challenge. *Jurassic Park* author Michael Crichton suggested getting dino DNA from blood-sucking insects that had been preserved in amber. The good news is that amber (fossilised tree sap) does sometimes contain well-preserved insects. The bad news is we can't get useful DNA this way. The problem is the half-life of DNA molecules.

DNA is a complex, fragile substance. Over time it breaks down, becoming less and less readable. A

team from the University of Copenhagen and Murdoch University in Perth found that in 521 years, half of a sample of DNA would be broken into useless fragments, after another 521 years another half and so on. This means that no part of a DNA sequence would be readable after 1.5 million years – far less than the 60 million plus required for resurrecting a dinosaur. Furthermore, a team at Manchester University that tried the insect-in-amber technique found that DNA degraded faster than normal in these conditions.

But there is hope for recently extinct mammals like the thylacine (Tasmanian tiger), which died out in the early 20th Century, or even 5,000-year-old mammoths, found preserved in permafrost. Not only can researchers find intact DNA to use, but there are also closer living relatives to act as host mothers. In fact, Prof Michael Archer of the University of New South Wales believes bringing back the thylacine is a distinct possibility.

"I'm hopeful, given the increasing frequency of major technological breakthroughs in synthetic biology, that it will be within the next 20 years," he says.

Some believe we will never clone a mammoth, despite there being two projects underway attempting just this. Other experts such as Dr Beth Shapiro, Associate Professor of Molecular Evolution at the University of California, Santa Cruz, are cautiously optimistic.

"It depends on what you are willing to call a mammoth," she explains. "If you are willing to accept an Asian elephant whose genome contains a very small



Preserved bodies of thylacines still contain viable DNA



Dr Beth Shapiro thinks that reverse engineering could help with de-extinction

amount of mammoth DNA – perhaps a few mammoth genes inserted in place of the elephant version of genes, so that an elephant is better able to survive in a cold place – then this could happen quite quickly. For mammoth de-extinction, the biggest challenge is probably not sequencing and assembling DNA or editing an elephant genome so that it looks more mammoth-like, but the later stages: implanting a developing embryo in a surrogate mom, having that pregnancy develop to term, rearing a newborn calf. These are challenges that not only do we not know how to solve, but that, ethically, remain questionable."

Starting with the DNA of an animal descended from dinosaurs – a big bird, for instance – scientists would try to produce the characteristics we know, or suspect, dinosaurs had by genetic engineering. The result might be something that looked and acted like a Tyrannosaurus rex, but that would not truly be one.

"CRISPR, Clustered Regularly Interspersed Short Palindromic Repeats, are short gene-like

sequences. They are often associated with a particular enzyme, Cas," explains palaeontologist Dr Henry Gee. "The CRISPR-Cas system – found naturally in bacteria – is a kind of immune system, allowing bacteria to resist invasion by viruses. In the past couple of years, it's become evident that the CRISPR-Cas system can be used for the precision editing of genetic material... in the science-fictional world of dinosaur genome reconstruction, it would be an essential part of the toolkit."

It might seem that an approximation to a dinosaur would be a pretty worthless animal, but Gee disagrees. "Given that almost everything we know about dinosaurs comes from bones, and everything else is a matter of guesswork anyway, who's to notice the difference?" he asks.

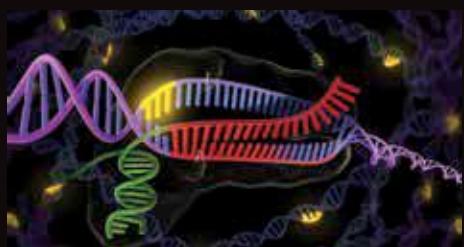
But not every expert is hopeful of success. Michael Benton, Professor of Vertebrate Palaeontology at the University of Bristol, thinks that practicalities would overwhelm any attempt to manufacture a dinosaur.

"Reverse engineering DNA could be done now by snipping out bits and inserting bits, but who is to provide the pattern for DNA of any dinosaur? I can see no way we can provide even a faint guess at their genome," he says. "Why bother? And, if we could, surely we have more important purposes to which to put the technology – like engineering out disease or

engineering in food productivity."

Predictably, Shapiro is more hopeful. "We now know the complete genome sequences of more than 50 species of birds, as well as alligators and crocodiles," she says. "Using these data, we can reconstruct, using a computer and models of how genomes change over time, what the most likely sequence of the common ancestor of birds was. We might then go into the genome sequence of a living bird and change it so that it looks like this common ancestor. For now, this is a thought experiment, of course."

While such a technique is not possible today, the rate of advances in gene technology mean it may be conceivable in 50 years. And, considering our love affair with dinosaurs, how could we resist?



CRISPR enzyme (green and red) binding to DNA and preparing to snip out the faulty part

# HOW TO REAR DINOSAURS TO MATURITY

Even with dinosaur DNA, the route to a fully-grown animal is complex. "To work properly, DNA has to be packaged," explains palaeontologist Dr Henry Gee. "Many parts of DNA are coiled around protein complexes called histones. The degree to which DNA is wrapped around histones has a bearing on which genes are turned on during development and when."

Gee adds that much of DNA is modified chemically, as part of a pattern called the epigenome. This is also vital in development. "The most important thing, however, is the early maternal environment. The earliest stages in the development of an embryo depend on chemical factors left in the egg by the mother. Even having the right factors in the right places within the egg is important," explains Gee. "As we don't have fresh dinosaur eggs to work with, we'd have to use crocodile or bird eggs. Scientists know an awful lot about chicken eggs, so perhaps they'd start with those."

Luckily, not all dinosaurs were on the scale of *Diplodocus* – there were plenty of chicken-sized dinosaurs that we could experiment with before jumping straight to the big boys. When it comes to rearing, we would need to be aware of species requirements – just as with birds.

"We know that some dinosaurs behaved very like birds with respect to nesting and incubation," says Gee. "We also know that reproductively active female dinosaurs underwent secondary remodelling of their bones, associated with providing calcium for the eggshells and embryos. So, in some cases at least, birds and dinosaurs behaved very similarly. But dinosaurs were very diverse, and it is possible that they had a range of reproductive habits, from full-on parental care, to laying eggs in a nest or mound and forgetting all about them."



Not all dinosaur eggs were as big as this



# HOW TO MANAGE THEM

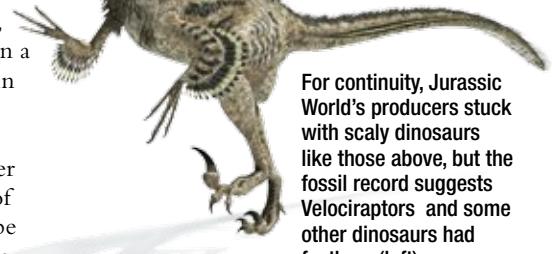


The owners of a dinosaur reserve would need to keep their animals safe and happy, while giving visitors a chance to see them as close-up as possible. The European Association of Zoos and Aquaria (EAZA) produces a detailed file on the management of each major species called an EEP (European Endangered Species Programme), which would need to be extended to include dinosaurs.

The difficulties of handling large dinosaurs are likely to be surprisingly similar to those faced when looking after large mammals – a fully-grown male African elephant can weigh up to seven tonnes, a similar weight to a T. rex. Although a large, grazing sauropod like a Diplodocus could weigh up to three times as much, they would be far slower. They would therefore provide less of an issue for any barrier than a high-speed predator. In practice, it's likely that the dinosaurs could be kept in place by using traditional concrete and rock barriers.

Bob Lawrence, Head of Wildlife Development at West Midland Safari Park, points out that one vital aspect of keeping animals secure is understanding the social grouping of the particular species. For

example, some tolerate a male hierarchy, but others only allow one mature male in a group. The latter scenario would result in battles where the loser would attempt to flee and could try to charge out of the enclosure, putting the containment under stress. With our limited understanding of dinosaur social groupings, there would be an initial need for an environment where



For continuity, Jurassic World's producers stuck with scaly dinosaurs like those above, but the fossil record suggests Velociraptors and some other dinosaurs had feathers (left)



According to Bob Lawrence, we must understand social groupings to keep animals safe and secure

security was paramount to avoid escapes.

Elephants are often confined using electric fences, but Lawrence points out that not only are these potentially inhumane, but more intelligent species can find ways to disrupt them. Elephants have been known to short them out using tree branches and there is always the possibility of technical failure. Steel barriers or high walls would need to be capable of withstanding the impact of charging dinosaurs. When housing elephants, about 2.5m is the recommended minimum height for a barrier, but in the case of taller dinos, this would have to be increased appropriately.

For smaller predators like Velociraptors, Lawrence recommends the kind of ▶

# WHERE TO PUT THE PARK AND HOW TO ENGINEER A HABITAT

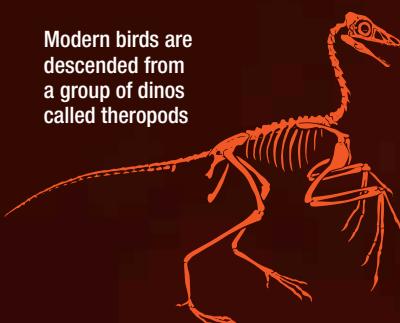
We tend to lump together dinosaurs as a single group of animals – but they lived over a huge time period from the Jurassic (200–145 million years ago) when massive herbivores like *Diplodocus* were common, through to the late Cretaceous (100–66 million years ago), when the likes of *T. rex* and *Velociraptor* thrived. Not surprisingly, the habitats varied. But generally the need would be for a warm, humid environment with plenty of coniferous trees and fern plantations.

However, it isn't always essential to match a habitat to an animal. With suitable winter protection, African animals can survive comfortably in British safari parks. And it may be that dinosaurs would be equally adaptable, although this is something that would require experiments with living animals to determine. With this in mind, the first park would require highly controlled and large-scale environments. As such, it wouldn't really matter where in the world the park was situated. The driving factor would more likely be the source of funding.

The key to the adaptability of the animals

would be whether they resembled warm-blooded birds, or cold-blooded crocodiles. A fully warm-blooded organism can cope with much wider ranges of climate, whereas cold-blooded animals require a more controlled temperature range to thrive. Although we have moved away from the idea that dinosaurs were cold-blooded, we still don't know for sure whether something like a *T. rex* had a full-scale warm-blooded metabolism or something in between the two, leaving it more susceptible to the cold. The only way we can find out for definite is by experiment.

Modern birds are descended from a group of dinos called theropods



fencing used for wolves, which typically involves a 45-degree inward overhang. This is essential when the animals can be good jumpers.

For smaller dinosaurs, existing bird enclosures would likely prove fine.

"One might have greater success with some of the smaller, feathered dinosaurs, no bigger than crows or pigeons, which could be kept in a large aviary," says Gee.

There is always going to be compromise, but good zoos and wildlife parks will have the animals' welfare at their heart. The trouble with dinosaurs is that so much would initially be a matter of guesswork.

Take the *T. rex*. For years this dinosaur with immensely powerful jaws was considered a straightforward predator. Yet some palaeontologists suggest that, like a hyena, it was almost entirely a scavenger and primarily lived off the kills of others. There is evidence to support both theories, which is typical of the uncertainty we face.

Equally, there is some evidence that *T. rex* indulged in cannibalism. After years of hard work, it would hardly be great news if one specimen ate the rest. Similarly, although it has been suggested that dinosaurs were less susceptible to disease than mammals, this is based on inference from the fossil record, which is patchy in the extreme.

With very large animals, there is also the problem of getting enough food into the enclosure at a time. A *T. rex* would probably need 40,000 calories a day, equivalent to eating a large goat. There's no reason why it couldn't cope with modern meat, though if it proved to be primarily a scavenger it would be more likely to be fed with, say, a cow carcass on a less frequent basis. Any sensible *T. rex* facility would have a failsafe mechanism for delivering food without having to risk physically entering the enclosure.

A large herbivore like *Diplodocus* probably had a diet of ferns and soft leaves – there would be considerably more concern about finding appropriate diets (think, for example, how fussy a panda is in requiring bamboo shoots). But whatever the exact plant life involved, an animal with this bulk would need large quantities of vegetation – perhaps half a tonne per day. In this case, the supply might be challenging, but at least the enclosure can be entered with less risk.

## FIVE FREEDOMS

Zookeepers refer to five freedoms of animals, which would inevitably be extended to dinosaurs. These are:

### 1. Freedom from hunger and thirst

Adequate, well-balanced and timed nutrition must be provided.

### 2. Freedom from discomfort

A suitable environment with shelter and appropriate materials allows animals to live as closely as possible to a natural environment.

### 3. Freedom from pain, injury and disease

Animals should not be put at risk by the enclosure and should have good access to veterinary medicine.

### 4. Freedom from fear and distress

These can be avoided by providing correct grouping and sex ratios, and including an appropriate mix

of species. There should be a lack of unnecessary confinement and places to escape from view.

### 5. Freedom to behave normally

In old-fashioned zoo environments, animals would pace unnaturally. Instead, they should have somewhere to express their natural behaviour as closely as possible.

# WHO WOULD RUN THE PARK?



**THE ANCIENT DNA EXPERT**

**DR BETH SHAPIRO**

Recreating dinosaurs would mean finding out as much as we could about their DNA and reverse engineering what we couldn't find. An expert in ancient DNA is an essential cast member, and Shapiro already has a project working on a form of reverse engineering.



**THE DE-EXTINCTION EXPERT**

**PROF MICHAEL ARCHER**

Archer and a small number of individuals are looking at the practicalities of producing a living specimen of an extinct creature. The work currently focuses on recently extinct mammals, but for the park that would have to be extended much further.



**THE PALAEONTOLOGIST**  
**PROF MICHAEL BENTON**

We can't get anywhere without an expert in dinosaurs. These scientists can help us discover remnants and will increase our understanding as much as possible. They can teach us about the lifecycles of the animals to give us the best chance of successfully rearing them.



**THE BACKER**  
**CLIVE PALMER**

This eccentric Australian mining billionaire is exactly the kind of backer that would be essential to get an ambitious project like this off the ground, as it would require a huge amount of funding. According to the Australian press, Mr Palmer has already expressed an interest in cloning dinosaurs.



**THE SHOWMAN**  
**SIR RICHARD BRANSON**

There is no doubt that the Virgin owner is an ultimate showman and he already owns a private game reserve, Ulusaba in South Africa, adjoining the Kruger National Park. Sir Richard's ebullient enthusiasm and media access make him an ideal candidate for launching a dinosaur park.

# VISITOR EXPERIENCE



Dinosaurs would be so valuable that the visitor experience would come second to security. Good walls, designed to look like natural structures, with viewing points and ports would give the best combination of safety and access. In a future Eden Project-style environment, there could be virtual robotic tours of the enclosures and the ability to fly over the top in a totally transparent vehicle.

We know already from dinosaur

exhibitions that there will be plenty of spinoffs. It's unlikely that the restaurant would serve actual mammoth or dinosaur burgers, but it would be possible to use the same technology that produced a £200,000 lab-grown burger to grow mammoth and dinosaur meat. Bear in mind that in less than two years, the price of making a lab burger has dropped to under £10. To accompany their meal, visitors might like a glass of the Fossil

Fuels Brewing Company's beer, claimed to be made using a yeast strain dating back 45 million years.

No doubt dinosaur toys making realistic sounds would be popular – but as yet, we have little idea of the noises that dinosaurs made. There has been speculation that strange bony head crests on some duck-billed dinosaurs were used to create resonant cries, but most dinosaur noises featured in movies and documentaries are simply reused from existing animals.

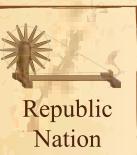
Palaeontologist Phil Senter has even suggested that dinosaurs may not have had cries at all. This is because their two living descendants, the birds and crocodilians, have totally different sound-making mechanisms from each other, suggesting their common ancestor may have had neither. But after the noise of the *Velociraptor* claws on the floor in *Jurassic Park* gave us nightmares, we'll be thinking twice about a dino attraction. ☐



**Brian Clegg** is a science writer whose most recent book is *Science For Life*.

## HISTORY OF INDIA

# DECade by Decade

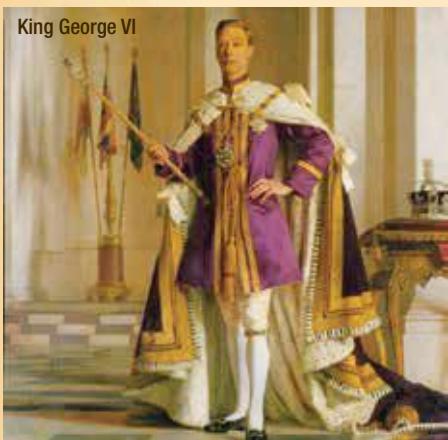


In the 68th year of India's Independence, **Moshita Prajapati** chronicles the significant political, cultural and social events that have shaped its present

## 1947 – 1949

### 18 July 1947

King George VI signs the Indian Independence Act.



### 15 August 1947

Dominion of India is established as an independent state.



The Hindustan Times front page 15 August 1947

### 22 October 1947

Pakistan Army advances towards the princely state of Jammu & Kashmir. A ceasefire is called into effect on midnight of 1 January 1949.

### 26 October 1947

Maharaja Hari Singh, ruler of Jammu & Kashmir signs the Instrument of Accession document acceding the state to the Dominion of India and Sheikh Abdullah becomes the Prime Minister of Jammu & Kashmir.

### 17 September 1948

The Nizam of Hyderabad accedes the princely state of Hyderabad into India.

### 21 June 1948

Lord Mountbatten resigns as the Governor-General of India.

### 30 January 1948

Nathuram Godse, a Hindu nationalist, assassinates Mahatma Gandhi.



Funeral procession of Gandhi, passing the India Gate, Delhi

### 26 November 1949

The Constitution of India drafted by Dr B R Ambedkar is adopted by the Constituent Assembly. It is the world's longest with 395 articles and 8 schedules.



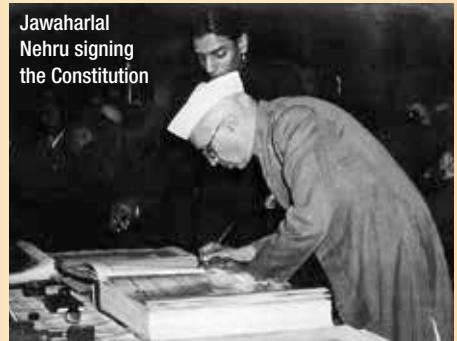
The original text of the Preamble, before the 42nd Amendment of the Constitution

## 1950 – 1959

### 25-26 January 1950

The Election Commission of India is established. The Constitution of India comes into effect and India is declared as a sovereign democratic republic nation.

Jawaharlal Nehru signing the Constitution



In **1951-52** the first general election is held and the Indian National Congress led by Jawaharlal Nehru wins 45 per cent of the vote and 75 per cent of the seats.

In **1951** the first Five Year Plan is initiated.

### 5 November 1951

Central Railways is created by merging small government-owned railways and Western Railways is created by merging small state-owned railways.

### 25 August 1953

Government of India becomes a major stockholder in Air India.

### 1 October 1953

Andhra Pradesh is the first state in independent India to have its borders formed on linguistic basis. It is carved out of the Telugu speaking regions of Madras Presidency.

### 3 January 1954

Bhabha Atomic Research Centre (BARC) is established but under the name (its original name) of Atomic Energy Establishment Trombay (AEET).

**21 March 1954**

The first Filmfare Awards are held honouring the best in Hindi cinema.

**29 April 1954**

India signs the Panchsheel Treaty (Five Principles of Peaceful Co-existence) with China in Peking.

In 1954 the Special Marriage Act of 1954 is tabled and passed in the following year. The act allows for a special form of marriage for all people of India and Indian nationals in foreign countries irrespective of religion and faith.

**1 November 1956**

The States Reorganisation Act, 1956, comes into effect. It is a major reform of the boundaries of India's states and territories, which organises them along linguistic lines.

**5 April 1957**

E M S Namboodiripad is the first member of the Communist Party of India to hold the position of Chief Minister of Kerala.

**11 September 1958**

Parliament passes the Armed Forces (Special Powers) Act (AFSPA).

**30 March 1959**

Tenzin Gyasto, the 14th Dalai Lama, flees Tibet and travels to India. His asylum worsens Indo-China relations.

**15 September 1959**

Doordarshan (DD), India's national state-owned broadcaster is established.

In 1959 Bajaj Auto obtains license from the Government to manufacture two- and three-wheelers in India. It becomes the largest three-wheeler manufacturer in the world.

**1960 – 1969****18-19 December 1961**

The Indian Army successfully annexes the Portuguese territories of Goa and Daman & Diu into the Republic of India.

**13 November 1963** The first Indian Institute of Management is established in Calcutta.

**20 October 1962**

Chinese troops invade Kashmir and capture Aksai Chin. India is underprepared for this invasion and on 21 November 1962, a

ceasefire is declared along the McMahon Line after China withdraws its troops.

**30 November 1963**

The state of Nagaland is created from Assam after a meeting with Naga People's Convention in 1960.

In March 1963 American agronomist Dr Norman Borlaug kickstarts the Green revolution in India by introducing a high yield variety of wheat.

**27 May 1964**

India's first and longest serving Prime Minister till date, Jawaharlal Nehru dies of a sudden heart attack. Gulzarilal Nanda is sworn in as acting Prime Minister.

**9 June 1964**

Lal Bahadur Shashtri is sworn as the second Prime Minister of India. He is first PM to raise the budget for agriculture following through on his campaign of *Jai Jawan, Jai Kisan*.

**29 August 1964**

The Vishwa Hindu Parishad, is founded based on the ideology of Hindutva. It is a non-governmental organisation.

**5 August 1965**

A second war erupts between India and Pakistan and Indian troops enter the city of Lahore on 6 September before a ceasefire is called.

**10 January 1966**

Lal Bahadur Shashtri and President of Pakistan Ayub Khan agree to the Tashkent Declaration, thus ending the 17-day war. Shashtri unexpectedly dies of a cardiac arrest the next day.

Indira Gandhi, the first and only woman Prime Minister of India

**24 January 1966**

Indira Gandhi becomes the fourth Prime Minister of India and the first woman to hold the post.

In 1966 the cousins Dhirajlal Hirachand Ambani and Champaklal Damani establish Reliance Industries Limited.

**19 June 1966**

Bal Thackeray forms Shiv Sena, a regional political party whose ideology is based on Marathi and Hindu nationalism.

**31 October – 1 November 1966**

Punjab and Haryana come into existence as two separate states with Chandigarh appointed as the capital for both.

**21 September 1968**

India's primary foreign intelligence agency Research and Analysis Wing (RAW) is formed and its first director is Rameshwar Nath Kao.

**12 November 1969**

Indira Gandhi is expelled from Congress for violating the party's code of discipline. She forms the Indian National Congress (O) with her supporters.

## 1970 – 1979

In **1970** Operation Flood is launched by the National Dairy Development Board with an aim to make India the world's top producer of milk.

### 16 March 1971

Indira Gandhi achieves a landslide victory in the 5th general elections on the strength of her *Garibi Hatao* campaign.

In **1971** Sanjay Gandhi, MD of Maruti Udyog Limited is awarded the contract to manufacture the people's car.



1st Edition Maruti Car

### 9 August 1971

Indira Gandhi breaks the non-alignment tradition and signs the Indo-Soviet Treaty of Friendship and Co-operation.

### 3 December 1971

India declares war against Pakistan after the latter bombs the former's air bases during the Bangladesh Liberation War. The war ends with an Indian victory and the creation of Bangladesh (formerly East Pakistan).

### 1 April 1973

The Government of India launches the Project Tiger campaign to save the Royal Bengal tiger from extinction.

### 11 May 1973

The film *Zanjeer* releases starring Amitabh Bachchan and introduces the angry young man archetype in Indian cinema.



Amitabh Bachchan

### 18 May 1974

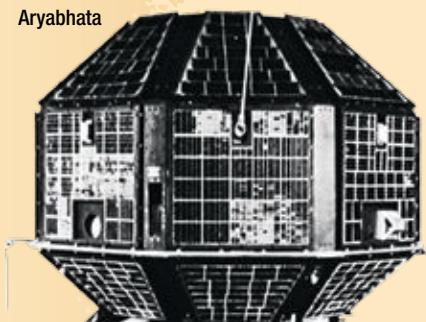
India becomes the first nation outside the UN Security Council to conduct its first nuclear weapon explosion test at Pokhran, Rajasthan.

### 12 June 1975

The Allahabad High Court finds the Prime Minister Indira Gandhi guilty of misusing government machinery during her election campaign. Following the court's verdict Jayaprakash Narayan calls for *Sampoorna kraanti* (Total Revolution).

### 19 April 1975

India's first satellite Aryabhata is launched into the Earth's orbit.



### 25 June 1975

President Fakhruddin Ali Ahmed declares a state of emergency across the nation, at Indira Gandhi's urging. Narayan, along with his supporters, are arrested on the same day.

In **9 July 1975** the Akali Dal launches the 'Campaign to Save Democracy' in protest of the emergency. Shiromani Akali Dal comes out in support.

### September 1976

Spearheaded by Sanjay Gandhi, a nationwide compulsory sterilization programme is implemented to control population explosion.

### 23 January 1977

Indira Gandhi announces the 6th general elections.

### 24 March 1977

For the first time after independence, the Congress party loses an election. Morarji Desai (of Janata Party) becomes India's first non-Congress Prime Minister. Following this, after 21 months, the Emergency officially ends. After the loss in the elections, Indira Gandhi breaks away from the Congress and forms her own party called Congress (I).

## 1980 – 1989

### 14 January 1980

Indira Gandhi returns to power and begins her third term as the Prime Minister of India. The following year, the National Election Commission declares Congress (I) as the real Indian National Congress.

### 6 April 1980

Bharatiya Janata Party is established.

### 23 June 1980

Sanjay Gandhi dies in a plane crash.

### July – August 1980

India wins the gold medal in hockey at the Moscow Olympics.

### 2 July 1981

Infosys is founded in Pune.

In **July 1982** Jarnail Singh Bhindranwale, leader of the Damdami Taksal and supporter of the Anandpur Sahib Resolution takes residence at the Harmandir Sahib Complex (inside the Golden Temple) and makes it his headquarters.



Jarnail Singh Bhindranwale

In **1983** Maruti Suzuki 800 is rolled onto the streets with the price tag of ₹35,000.

### 25 June 1983

India wins the Prudential World Cup, now known as the ICC Cricket World Cup.



Kapil Dev lifts the World Cup 1983 for India

**2 April 1984**

Squadron Leader Rakesh Sharma is launched into space, aboard the Soyuz T-11.

**5 June 1984**

Indian army storm into the Golden Temple during Operation Blue Star. After five days of conflict, they successfully take control of temple. Bhindranwale and his followers are killed in action.

**31 October 1984**

Indira Gandhi is assassinated by her bodyguards, Sawant Singh and Beant Singh, at her residence. Rajiv Gandhi is immediately sworn in as the seventh Prime Minister of India.

**31 October 1984**

A series of attacks against the Sikhs in Delhi and across the country are perpetrated by Congress supporters as retaliation for Indira Gandhi's death. The anti-Sikh riots go on till 3 November 1984. 2800 deaths are reported.

**2-3 December 1984**

The first day of the gas leak from the Union Carbide India Limited plant in Bhopal exposes 500,000 people living in nearby areas to the poisonous methyl isocyanate.



42 tonnes of the poisonous MIC gas leaked from tank E610, seen above, after the decontamination operation

**23 May 1985**

Under the background of the Punjab Insurgency, Parliament passes the Terrorist and Disruptive Activities (Prevention) Act (TADA).

**30 July 1987**

The first batch of India's Peace Keeping Force reaches Sri Lanka to combat the Liberation Tigers of Tamil Eelam (LTTE) waging a civil war in Sri Lanka.

In **1988** Voting age is lowered to 18 years.

**2 December 1989**

V P Singh of the Janata Dal becomes the eight Prime Minister of India.

**1990-1999****22 January 1990**

The Central Bureau of Investigation files a formal complaint in the case regarding the Bofors deal.

**24 September 1990**

Surinder Singh Chauhan self-immolates to protest against the implementation of the Mandal Commission, which looked at implementing 49.55% of quota for OBC in government jobs and public universities.

**21 May 1991**

Former Prime Minister Rajiv Gandhi is assassinated by a LTTE Suicide Bomber in Sripurumbudur in Tamil Nadu during the election campaign.

**21 June 1991**

P V Narasimha Rao becomes the tenth Prime Minister of India. He heralds the dismantling of the Licence Raj system and liberalizes the economy of India with Dr Manmohan Singh as his Finance Minister.

**24 June 1991**

J Jayalalithaa is sworn in as chief minister of Tamil Nadu for the first time.

**6 December 1992**

Hindu Kar Sevaks entirely destroy the 16th century Babri Masjid at Ayodha.

**10 March 1993**

The All Parties Hurriyat Conference is formed in Kashmir.

**12 March 1993**

13 serial bomb explosions rock Bombay. Dawood Ibrahim is believed to have masterminded the act.

**3 May 1995**

Delhi Metro Rail Corporation is set up.



In **1995** internet access was made public to the citizens of India by Videsh Sanchar Nigam Limited.

**16 May 1996**

BJP forms coalition government under India's eleventh Prime Minister Atal Behari Vajpayee. However, the party does not receive an overall majority and Vajpayee resigns thirteen days later, and is replaced by the United Front, led by Deve Gowda.

In **1997** Sonia Gandhi, Italian-born widow of Rajiv Gandhi, announces her decision to join the Congress election campaign and is elected as the party president in 1998.

**5 July 1997**

Lalu Prasad Yadav announces the formation of a new party called Rashtriya Janata Dal

**19 March 1998**

BJP emerges as the winner in the 1998 general elections and Vajpayee is again elected as Prime Minister.

**11-13 May 1998**

India conducts five underground nuclear tests dubbed Pokhran II.

**19 October 1998**

*Dilwale Dulhania Le Jayenge* starring Shahrukh Khan and Kajol releases.

**21 February 1999**

PM Vajpayee and President Musharaff sign the Lahore Declaration, a bi-lateral agreement and governance treaty between India and Pakistan.

**26 May 1999**

India declares war on Pakistan after the latter captures the former's territory of Kargil. The two-month conflict ends with an Indian victory.

## 24-31 December 1999

Indian Airlines flight IC814 is high jacked by terrorists and flown to Kandahar, Afghanistan. The passengers are eventually released in exchange for the release of terrorist Maulana Masood Azhar.



## 2000-2009

In **May 2000** India's population officially crosses a billion citizens.

### 13 December 2001

A squad of suicide terrorists, later identified as members of the Lashkar-e-Taiba and Jaish-e-Mohammed terror group, attack the Indian Parliament.



### 25 January 2002

India successfully tests the nuclear capable ballistic missile, Agni I, on Wheeler Island off its eastern coast.

### 28 February 2002

Day 1 of Godhra riots. Gujarat is plunged into three-day communal riots following the death of 59 people who perished in fire inside the Sabarmati Express.

### 25 July 2002

A P J Abdul Kalam is elected as the eleventh President of India.

### 13 May 2004

In a surprise result, Congress is declared as the winner of the 14th general elections. Manmohan Singh is sworn in as fourteenth Prime Minister and the head of the UPA coalition government.

### 2 February 2006

Mahatma Gandhi National Rural Employment Guarantee Act is put into effect, which aims to guarantee the 'right to work' to every household, whose adult members volunteer to do unskilled manual work.

### 11 July 2006

Seven coordinated bomb blasts within 11 minutes of each other inside Mumbai trains kill 180 people. Investigators blame Pakistani militant groups.

### 25 July 2007

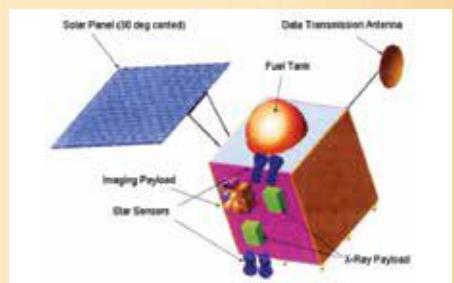
Pratibha Patil becomes first woman President of India.

### 1 October 2008

The US Senate approves the India-United States Civil Nuclear Agreement, which allows India to purchase and sell nuclear fuel and technology from US for its civilian purpose.

### 22 October 2008

India successfully launches its first mission to the moon, the unmanned lunar probe Chandrayaan-1.



Model of Chandrayaan-1 spacecraft

### 26 November 2008

10 members of Lakshar-e-Taiba carry out a series of twelve co-ordinated shootings and bombings in Mumbai.

### 2 July 2009

A Delhi court rules that homosexual intercourse between consenting adults is not criminal, overturning a 148-year-old colonial law.

## 2010 – 2015

### 7 June 2010

The Supreme Court finally passes judgment in the case pertaining to the Bhopal Gas Tragedy, 25 years after the event.

### 3 May 2010

Pakistani terrorist Ajmal Kasab is found guilty of 2008 terror attacks in Mumbai and sentenced to death.

### 30 September 2010

The long-running Ayodhya dispute is settled in the Allahabad High Court; the verdict sees the land get divided into equal thirds allotted to Hindu Maha Sabha, Sunni Waqf Board and Nirmohi Akhara.

### 26 December 2006

A tsunami kills thousands from coastal communities in the south of India and in the Andaman and Nicobar Islands.

**3 – 14 October 2010**

The XIX Commonwealth Games are held in Delhi. The event is plagued with controversies over corruption.

**2 April 2011**

The Central Bureau of Investigation files a charge sheet against the politicians and bureaucrats accused in the 2G scam.

**20 May 2011**

Mamata Banerjee pulls off a landslide victory for the TMC Congress alliance in West Bengal by defeating the 34-year old Communist Party of India (Marxist)-led Left Front government, the world's longest-serving democratically elected communist government.

**4 April 2011**

Anna Hazare leads the massively popular Jan Lokpal movement, raising the issue of corruption and demanding more accountability for public servants.

**26 November 2012**

Lokpal movement leads to the formation of the Aam Aadmi Party founded by Arvind Kejriwal.

**16 December 2012**

A violent gang rape and murder in Delhi prompts a national outcry over the plight of women in the country, leading to nationwide agitation. Dubbed the Nirbhaya Movement, enraged citizens call for harsher punishment for rapists and more security for women.

**11 December 2013**

The Supreme Court revokes the Delhi High Court's overruling of section 377, making homosexuality a criminal offence in India once again.

**8 December 2013**

The fledgling AAP wins the fifth Legislative Assembly of Delhi, forming a minority government in the city. This government lasts only 49 days before being dissolved.

**16 May 2014**

The Narendra Modi-led BJP comes to power with an overwhelming majority in the 16th General Elections. The Congress faces its worst defeat in India's history.

**2 June 2014**

Telangana is created as the 29th state of India.

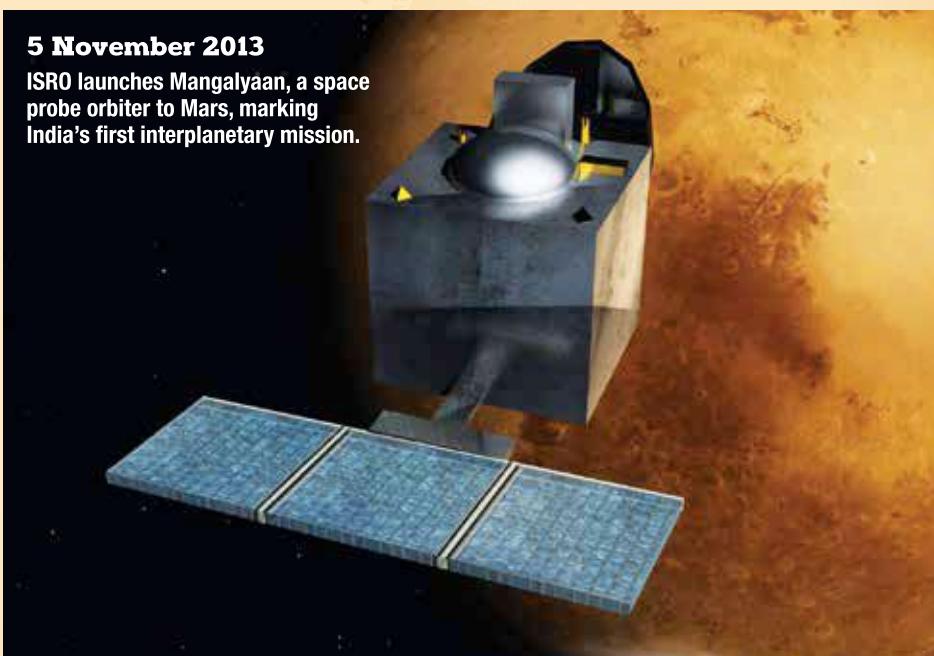
**10 February 2015** The Aam Aadmi Party wins the Delhi general election for a second time, following a landslide victory over the BJP and Congress.



LGBT activists protest against Supreme Court's judgement

**5 November 2013**

ISRO launches Mangalyaan, a space probe orbiter to Mars, marking India's first interplanetary mission.



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# HUBBLE'S TOP 10 DISCOVERIES



The Hubble Space Telescope has been observing the Universe for a quarter of a century. Amy Tyndall takes a look at some of its most incredible discoveries

**T**wenty-five years ago, one of the most famous and awe-inspiring pieces of technology – The Hubble Space Telescope – was launched.

Hitching a ride with the Space Shuttle Discovery in 1990, Hubble was placed in low-Earth orbit, where it has been continuously observing the night sky ever since. Observations have been carried out across all wavelengths of light, from ultraviolet to infrared, which have given astronomers an unprecedented window on the Universe.

But what have they learned from its breathtaking pictures? To find out, we polled 100 professional astronomers around the world, and the results are in...

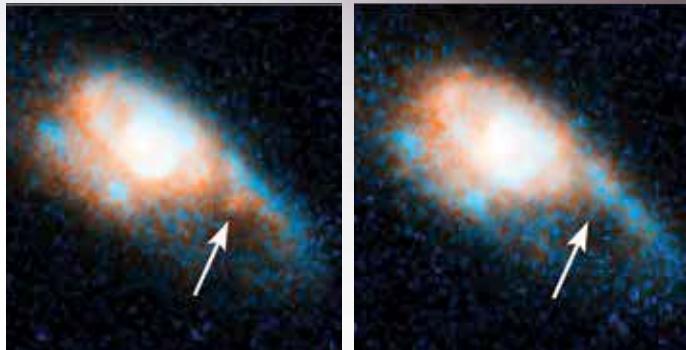
# 10

## CAUSE OF GAMMA-RAY BURSTS

The fuzzy-looking galaxy to the right was home to one of the most energetic events in the Universe: a gamma-ray burst (GRB). These flashes of gamma-ray radiation are an enigma because they're so rare - a typical galaxy produces only a few every million years. Yet they release as much energy in a few seconds as our Sun does in 10 billion years. On 3 June 2013, a GRB lasting one-tenth of a second occurred, and was spotted by NASA's Swift satellite. When Hubble looked 10 days later, it found an infrared glow where the burst had been. But by 3 July it had faded. This disappearing glow was the dying embers of another kind of cosmic explosion - a kilonova - believed to be the result of extremely dense stars called 'neutron stars' merging. Since the kilonova was found in the same location as the GRB, it was the 'smoking gun' revealing that short GRBs could well be caused in the same way. The kilonova was investigated by Prof Nial Tanvir of Leicester University, who says Hubble played a vital role. "Although Swift discovered this particular short gamma-ray burst, and observations from ground-based telescopes gave us its precise position and distance, Hubble was the only option for seeing the faint kilonova emission."

"Gamma-ray bursts release as much energy in a few seconds as our Sun does in 10 billion years"

⊖ An infrared glow was spotted on 13 June 2013 (left) but had faded by 3 July (right)



# 9

Comet Shoemaker-Levy 9's impact (dark spots) could be seen on Jupiter

## HOW PLANETARY COLLISIONS WORK

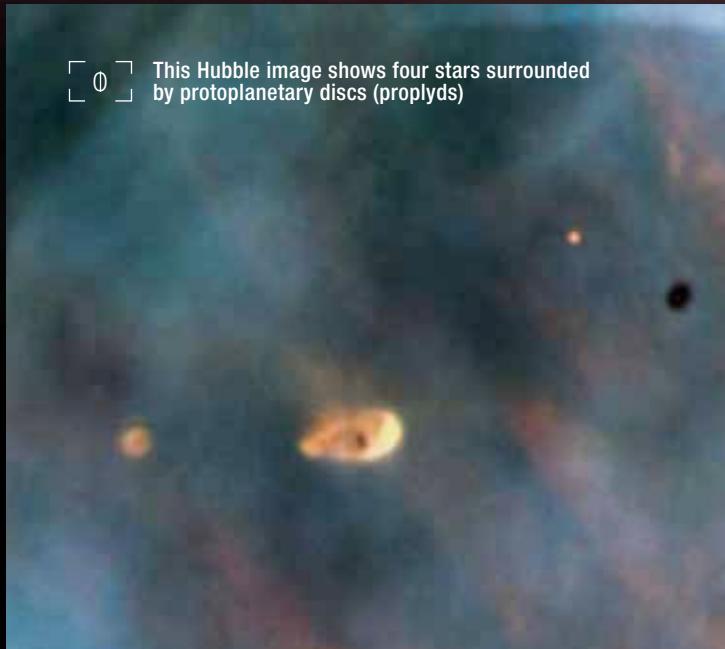
On 16 July 1994, telescopic eyes were turned on Jupiter as the first of 21 fragments of the broken-up comet, Shoemaker-Levy 9, crashed into the planet. Blotches scarred the atmosphere for a month before fading away.

Hubble's observations provided a wealth of information about Jupiter's atmosphere. "Obvious waves emanated from the largest impacts, like ripples in a pond. From this, we could make deductions about the deep atmosphere and water below the clouds," explains Dr Amy Simon,

senior scientist for planetary atmospheres research at NASA Goddard.

While ground-based observatories were also involved, Hubble was the only one that could look across an entire range of wavelengths, irrespective of the time of day or weather conditions. Ultraviolet was particularly important for imaging dust and aerosols whipped up by the impacts. "Hubble observed leftover debris and molecules high in the atmosphere for months, and even years, afterwards," says Dr Simon.

# 8



∅ This Hubble image shows four stars surrounded by protoplanetary discs (proplyds)

∅ Protoplanetary discs (like the one in this artist's impression) are where planets are born. They shed light on the early Solar System



## PROTOPLANETARY DISCS

Looking like little islands, these flat discs of cold dust and gas are left over from the formation of a new star in the Orion nebula. Although part of this material will be lost over time, some will eventually clump together in pebble-sized grains before potentially building up to form a baby planet. As such, they are known as protoplanetary discs, or 'proplyds'. By learning about proplyds, astronomers hope to find out more about the formation of Earth and the other planets. "This what our Solar System looked like in its infancy," says Prof C Robert O'Dell, who made this image. Ground-based telescopes had previously detected the objects, which were initially believed to be stars. The idea that they were discs of material surrounding the star goes back to the 1700s, but confirmation didn't come until the late 1980s, when astronomers managed to detect the disc through observations of its molecules. Hubble provided the breakthrough – directly imaging numerous proplyds for the first time within the Orion nebula.



□ 0 □ Hubble reveals individual stars in the galaxy M81, including Cepheid variables that were used to determine that the Universe is 13.8 billion years old

## THE AGE OF THE UNIVERSE

This spiral galaxy, M81, was the first of many galaxies observed by Hubble to find the expansion rate, and therefore the age, of the Universe. "Before the launch of Hubble, there was a heated debate over whether the Universe was 10 or 20 billion years old," says Prof Wendy Freedman, an

astronomer at The University of Chicago. Freedman set out to measure Cepheid variable stars - pulsating stars, whose brightness increases and decreases over a timescale of days to months. By determining the relationship between a Cepheid's brightness and its pulsation rate, it is possible

to estimate its distance. Cepheids are the most accurate way of measuring the distances to galaxies, and for setting the expansion rate of the Universe.

The Hubble measurements helped to determine that the age of the Universe is 13.8 billion years.

# 6



0

The blue stream of material is being ejected from a black hole at the centre of the M87 galaxy

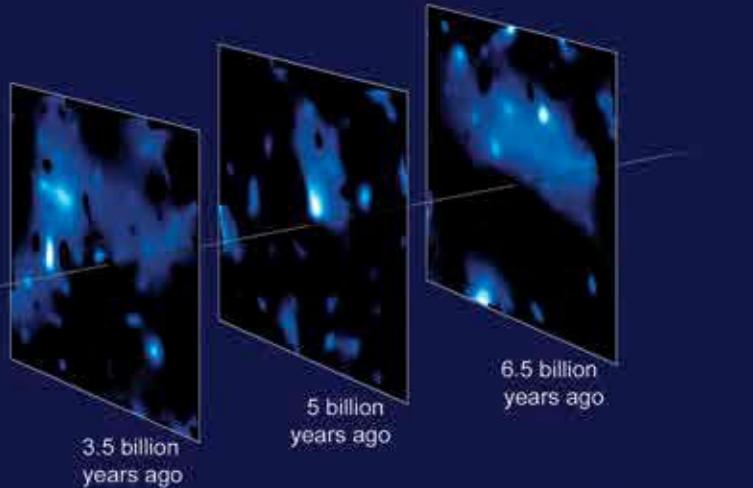
## SUPERMASSIVE BLACK HOLES

Black holes are difficult to find. Their intense gravitational force is so strong that not even light can escape their pull, making them ‘invisible’. But by measuring the speed of material that surrounds a black hole, it is possible to calculate its mass using the laws of gravity. If there is more mass than is accounted for by the stars we see, the rest could be due to a black hole. By the early 1990s, it was suspected that a supermassive black hole (SMBH) was at the centre of a handful of galaxies. “Soon after its launch, Hubble confirmed earlier SMBH detections by taking images five times sharper than those obtained from the ground,” explains Dr Marc Sarzi, an astronomer at the University of Hertfordshire. Hubble became known as a ‘black hole hunter’, due to its ability to measure the speed of surrounding gas and stars. Results from its observations were surprising, says Dr Sarzi. “SMBHs have a radius comparable to that of our Solar System, and yet can only directly affect the motion of stars and gas in the very central regions of their host galaxies,” he says. It suggests they evolved together, he explains. “It has turned SMBHs from being exotic curiosities to an integral part of our understanding of galaxy formation.”

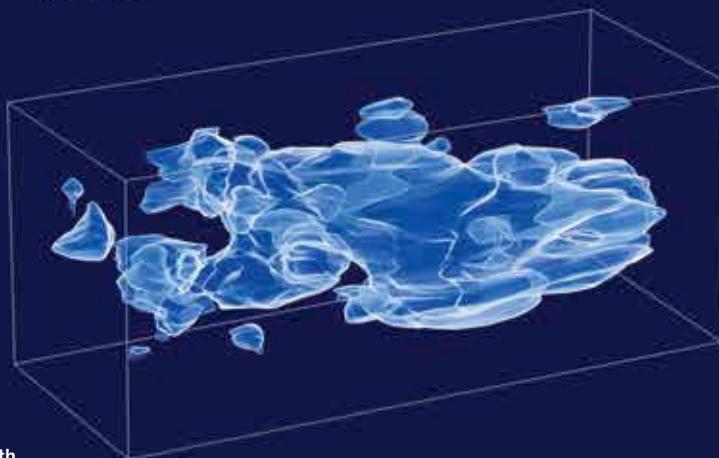
**“The history of astronomy is a history of receding horizons”**

Edwin Powell Hubble, 1936

# 5



Hubble allowed scientists to create this 3D map of dark matter – the distance from Earth increases from left to right



## DARK MATTER

NASA/ESA

This picture reveals the presence of something we can't see: 'dark matter'. The galaxies, stars and planets that we can see make up just 15 per cent of the Universe's matter. The rest - the other 85 per cent - is dark matter and it neither emits nor absorbs any known wavelength of light. "With this map, we saw for the first time where dark matter is," says Durham University physicist Dr Richard Massey. To construct it, half a million galaxies were observed by Hubble and ground-based telescopes. "When light travels across the Universe, it passes through all the intervening dark matter on its way to us, leaving a telltale imprint of its journey."

You can't see such faraway, faint galaxies from Earth because the atmosphere blurs the detail. This is why we needed Hubble," explains Massey. The dark matter bends the light in a 'gravitational lensing' effect, making the galaxies appear distorted. By observing this, it's possible to deduce where dark matter lies. Such a map is fundamental to understanding the Universe's structure, as dark matter acts as 'scaffolding', along which galaxies are assembled. "When the first explorers reached the American West, they sat on a ridge and tried to understand the lie of the land. We were doing the same thing on a new frontier," says Massey.

# 4

## GENERATIONS OF STARS

Globular clusters are compact crowds of hundreds of thousands of stars bound together by gravity. For many years it was believed that all the stars within must be very similar, having formed close together from the same dusty cloud. But in 2005, Hubble measured the brightness and colours of stars inside the NGC 2808 globular cluster. Only one generation of stars was expected, but three were found.

Dr Giampaolo Piotto was the leader of the team that observed NGC 2808. "With an age up to 13.5 billion years – only 300 million years less than the age of the Universe – globular clusters are a

**"You can't see such faraway, faint galaxies from Earth because the atmosphere blurs the detail"**

benchmark for cosmology, and represent an ideal laboratory to understand star formation and chemical evolution in the Universe," he explains. What defines the different generations of stars, also known as 'stellar populations', are characteristics such as their chemical composition, age, and their location in the cluster. Hubble's high-resolution images allowed Dr Piotto and his team to look into the densely packed core of NGC 2808 and measure many stars – something that is difficult for ground-based telescopes to do. Hubble's power to observe in both visible and ultraviolet light also made it easier to spot multiple populations of stars and track their evolutionary paths.

"We have now used Hubble to observe more than 60 globular clusters – almost half the known globular clusters in the Milky Way. Preliminary results show that all have multiple stellar populations," says Dr Piotto.



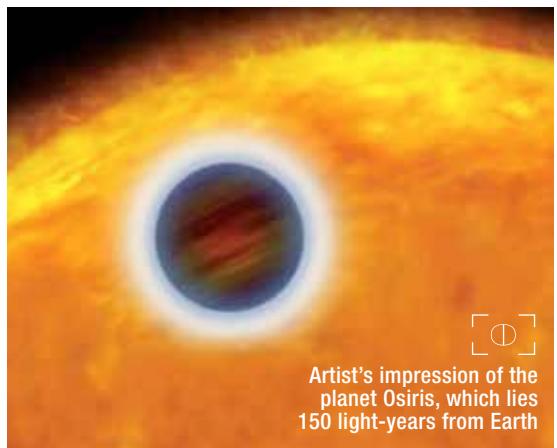
The NGC 2808 globular cluster contains over one million stars of three different generations

## EXOPLANET ATMOSPHERES

# 3

As of February 2015, 1,890 planets had been detected orbiting stars other than our Sun. An impressive photo of one of these 'exoplanets' has yet to be taken, but Hubble was first to detect the atmosphere of one of these alien worlds.

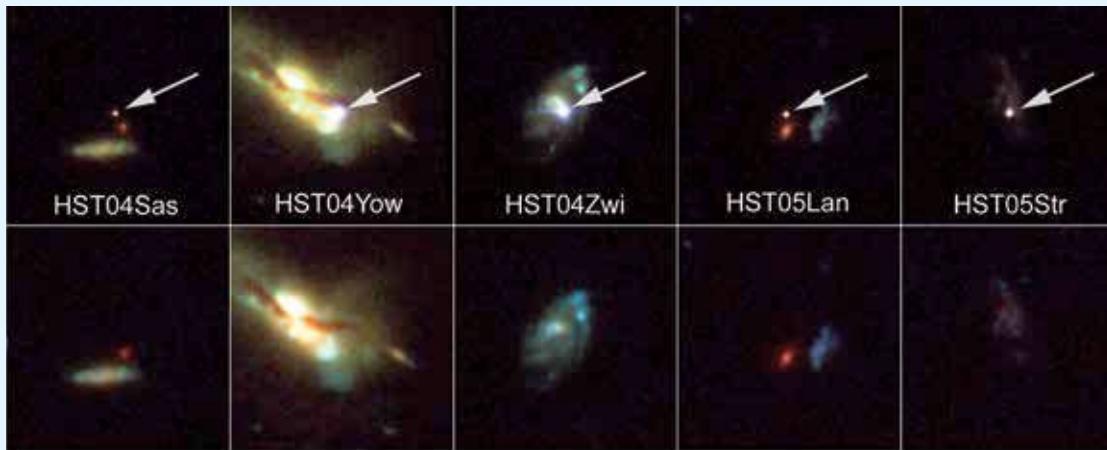
HD 209458-b, also known as Osiris, is a planet 150 light-years from Earth. Temperatures reach a scorching 1,100°C as it orbits just 6.4 million kilometres from its parent star. As the orbiting planet moves in front of the star, some of the light passes through the planet's atmosphere. This is analysed by a spectrograph, which is an instrument that splits the light into constituent wavelengths, explains Prof David Charbonneau, leader of the team behind the discovery. "The idea was to gather spectra when the planet was in front of the star and when it moved away. By comparing them, we would search for the appearance of new features when the planet was in transit. This required an extremely stable platform that was free from the absorption effects of our atmosphere. Only



Artist's impression of the planet Osiris, which lies 150 light-years from Earth

Hubble could do it!" In 2001, the procedure revealed signs of sodium – the first atmospheric element detected on a planet outside of our Solar System.

"This same method has become the standard means to examine exoplanet atmospheres, and Hubble has now gathered similar data on dozens of worlds," says Charbonneau.



## ACCELERATING EXPANSION OF THE UNIVERSE

These galaxies, hosting energetic supernovae (exploding stars), contributed to one of the most talked-about discoveries in recent years. Not only is the expansion of the Universe accelerating, it is being fuelled by a phenomenon dubbed 'dark energy'.

In 1998, astronomers released new data on how the brightness of supernovae changed over time. It showed that the light coming from the most distant exploding stars was fainter and more stretched (red-shifted) than predicted. It meant that they were further away than astronomers calculated – a result that didn't fit with the existing idea that the tug of gravity was causing the expansion of the Universe to slow down. For the team leading the project, this could only mean one thing: the expansion rate is not slowing at all. It's speeding up.

Hubble played a supporting role in this initial discovery by providing data for three of the supernovae that the team wanted to observe, with the

rest coming from ground-based telescopes in Chile, Europe and the USA. "This result was so extraordinary that it required extraordinary evidence," explains Dr Adam Riess, one of the three Nobel prize-winning team members for the discovery. "This confirming evidence came from the Hubble Space Telescope."

By finding and precisely measuring another 16 supernovae at distances up to 10 billion light-years away, Hubble was able to confirm not just the acceleration, but that the Universe had indeed been decelerating in earlier times, just as predicted.

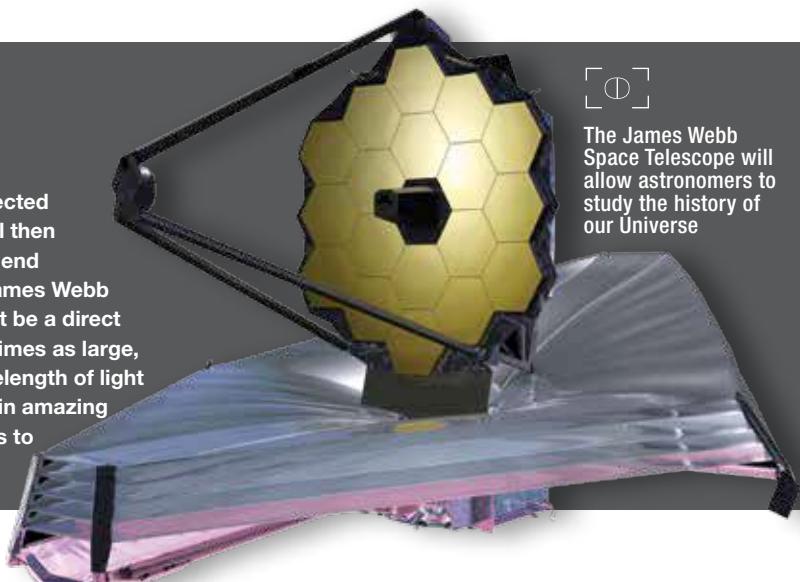
But to overcome gravity, something must be giving an opposing, repulsive force as the Universe expands and matter is spread out. This 'something' is dark energy, which makes up approximately 75 per cent of the entire known Universe. Hubble observations showed that this caused the acceleration we see today to begin about five billion years ago.



The arrows point to the supernovae; the bottom row shows the galaxies after the stars exploded

## BEYOND HUBBLE

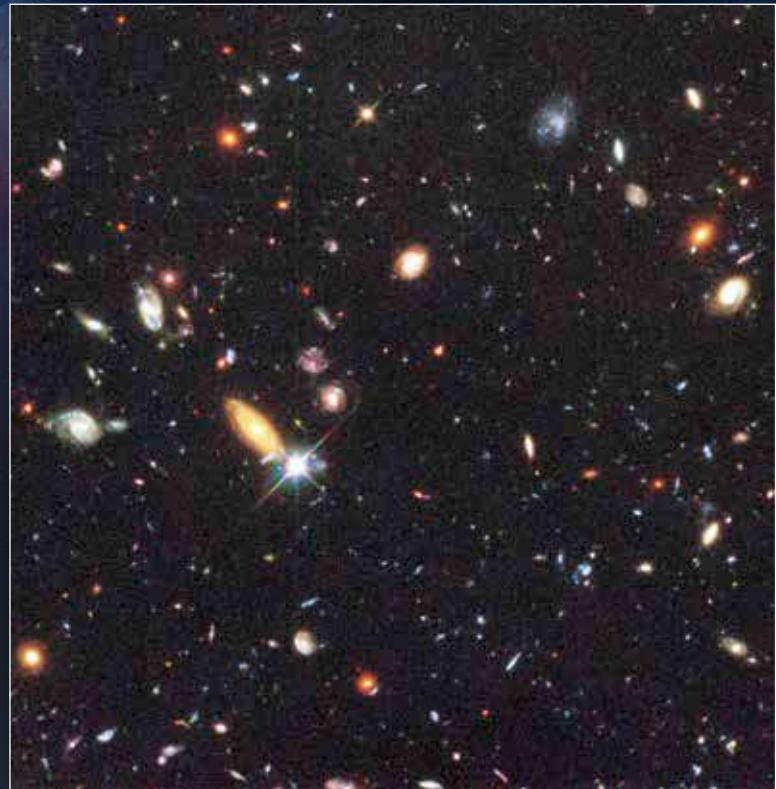
Hubble underwent its last servicing mission in 2009 and is expected to remain operational until it degrades around 2020. Hubble will then be sent into a final orbit back down into Earth's atmosphere to end its years of service in a blaze of glory. The highly anticipated James Webb Space Telescope (JWST) is due for launch in 2018, but it will not be a direct replacement for Hubble. Despite having a mirror almost three times as large, JWST will observe at a similar resolution but in a different wavelength of light – the infrared. It will be able to observe cold and dusty objects in amazing detail that previously appeared 'invisible', allowing astronomers to see further out into space, and back in time, than ever before.



The James Webb Space Telescope will allow astronomers to study the history of our Universe



Zooming in on a tiny patch of sky – the Hubble Deep Field. An incredible 3,000 galaxies of different sizes can be seen



## HOW GALAXIES EVOLVE

This awe-inspiring image, dappled with beautiful shapes and a whole array of colours, changed the way we think about the distant Universe forever. One of Hubble's most famous images, the Hubble Deep Field (HDF) is a snapshot of a tiny patch of sky in the constellation Ursa Major. It covers an area of just one 24-millionth of the whole sky. And yet this minute window reveals around 3,000 galaxies crowded together, giving astronomers a vital window into the past.

There had been predictions that the light emitted from such distant objects would be stretched out so much that they would appear as nothing more than faint smudges against the blackness. They could not have been more wrong. This image, made up of 342 separate exposures taken over more than 100 hours, showcased the power of Hubble. It revealed an incredible amount of detail and structure to galaxies that had never been seen before.

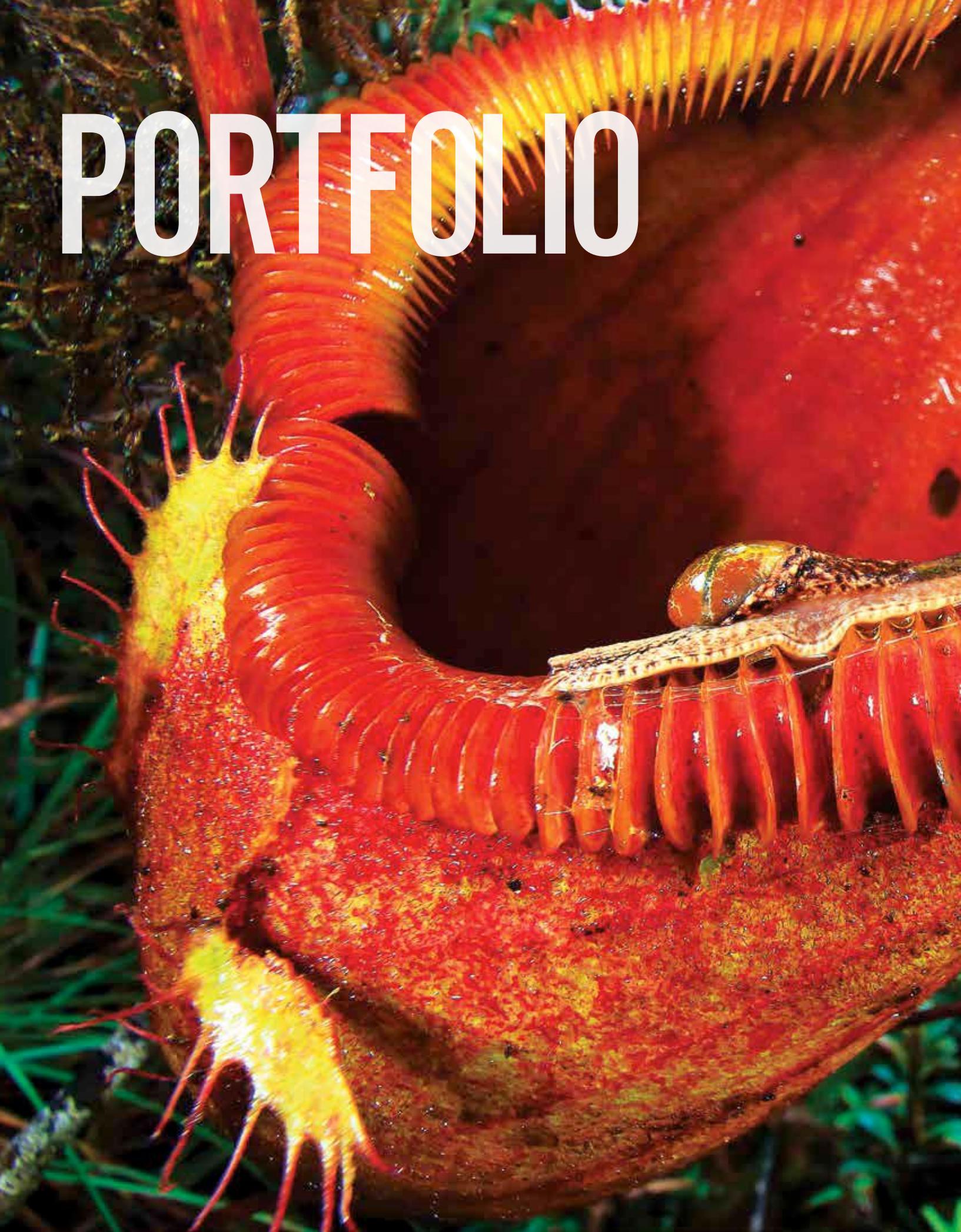
"A lot of astronomers were sceptical that we

would learn a lot from simply pointing the telescope at a fairly arbitrary spot in the sky and taking long exposures," says Dr Henry Ferguson, a member of the original HDF team. However, the plethora of information that appeared convinced most that this was a good technique. As the telescope's capabilities were upgraded, projects such as the Hubble Ultra Deep Field continued where HDF left off.

Today, astronomers are finding galaxies from a time when the Universe was only 500 million years old. As a result, it has become possible to chart galaxy evolution directly, by measuring how properties such as size, shape and colour change over time. "The HDF became one of the major 'watering holes' for studying galaxy evolution, with deep observations spanning X-ray to radio wavelengths," continues Dr Ferguson. "It is one of the most important observations ever made with any telescope!"

**Amy Tyndall** is an astronomer and works for the European Southern Observatory.

# PORTFOLIO





A slug crawls along the rim of a Kinabalu pitcher plant on Mount Kinabalu at approximately 2,900m. The plant is one of five endemic species here in the genus *Nepenthes*. Slugs are potential food for pitcher plants, but the plants can also offer useful habitat

# Symbiotic carnivores

The carnivorous pitcher plants found in the forests of Borneo have evolved incredibly intricate relationships with the species around them, says photographer and scientist **Christian Ziegler**



Pooled water is rare along the very steep slopes of Mount Kinabalu, so it's no wonder that a few species of frog use pitcher plants as spawning grounds. They have evolved an immunity to the plants' digestive liquids so that their tadpoles can develop in them. This photo shows a fringed pitcher plant *N. tentaculata*.

This cross-section of a stem of the fanged pitcher plant *N. bicalcarata* in Brunei, north-west Borneo, shows carpenter ants *Camponotus schmitzi*. The plant provides a home to a small colony of ants (up to 30 or so individuals), which keep the chemistry of the pitcher liquid balanced.



The Endangered Rajah's pitcher plant *N. rajah* is the largest in its genus, containing as much as three litres of liquid. Its lid has nectar glands that attract the tree shrew *Tupaia montana* (pictured) and nocturnal rats. The small mammals often defecate and urinate over the opening of the pitcher – a valuable source of phosphorus and nitrogen.





The fanged pitcher plant

*N. bicalcarata* is found in lowland peat forests in northern Borneo.

Some animals have evolved to use its pitchers as a home and hiding place, such as this small land crab.



Worker carpenter ants *Camponotus schmitzi* pull a dead grasshopper out of the liquid of a pitcher belonging to a fanged pitcher plant *N. bicalcarata*. Such a large prey item would overwhelm the plant's digestive abilities and cause it to rot.



#### Hardwicke's woolly bat

*Kerivoula hardwickii* uses the pitchers of *N. hemsleyana* as a day roost. This is a beautiful example of symbiosis – the pitchers' shape and very shallow filling of liquid allows the bat to sleep in it without drowning, while the mammal's excrement supplies welcome nutrients to the plant.



The flask-shaped pitcher plant *N. ampullaria* is a curiosity – it eats plants. The enzymes in its pitcher are best suited to digesting plant material, and the shape of the lid allows small twigs and leaves to fall in.

## THE LOCATION

### Kinabalu Park

Most of the images in this Photo Story were taken in Kinabalu Park, which is located on the west coast of Sabah in the north of Malaysian Borneo. The national park covers 754km<sup>2</sup> surrounding Mount Kinabalu, and is a World Heritage Site. Kinabalu Park contains a wide range of habitats and is a biodiversity hotspot with more than 4,500 species of flora and fauna.



## PHOTOS BY

**Christian Ziegler** is a photojournalist specialising in natural history. A tropical ecologist by training, he has worked extensively in rainforests on four continents, and since 2001 has been associate for communication with the Smithsonian Tropical Research Institute. Christian also participates in educational initiatives. He lives on the edge of a rainforest in central Panama. [www.naturphoto.de](http://www.naturphoto.de)

## HOW DO WE KNOW?

# THE STRUCTURE OF HUMAN CELLS

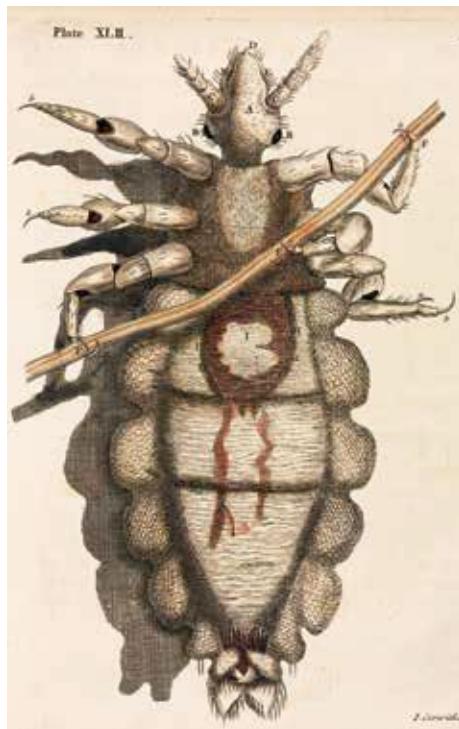
BY KATHERINE NIGHTINGALE

The invention of the microscope kick-started a scientific journey of discovery into the world of the very small that culminated in our understanding of the building blocks of the human body

When people think of scientists, they often think of people in white coats peering down microscopes. That's no surprise – the microscope has been instrumental to finding out what's inside us. The first microscope came from the Dutch city of Middelburg around 1590. This was a time of great interest in the power of lenses, whether for spectacles, magnifying glasses, telescopes or microscopes. Some would use these new technologies to gaze into the heavens. Others peered inwards, instead staring into the 'microcosmos', the world of the cells inside us.

During the 1600s, scientists began to study all kinds of materials under their microscopes. Not least of these was Robert Hooke, who in 1661 was passed a royal commission to study insects. Hooke set about designing a new type of microscope for the job. With its three lenses, it magnified objects by 50 times.

He studied insects and materials, producing brilliant technical drawings for his *Micrographia* book, published in 1665. *Micrographia* also holds Hooke's most significant contribution to cell biology. When peering down his microscope at a thin sheet of cork, he saw what appeared to be many empty spaces



A louse clinging to a human hair is one of the remarkable images that features in Robert Hooke's *Micrographia*

bound by wall-like structures. Reminded of the small rooms in which monks dwell, he named them 'cells'.

Perhaps drawn to microscopy after seeing Hooke's studies of fabrics, Dutch tradesman Antonie van Leeuwenhoek became adept at grinding lenses, making them with such precision that he could magnify objects to 270 times their size. His microscopes used just a single, tiny spherical lens, and gave him unprecedented access to the hidden world.

In 1675 he found single-celled lifeforms – now called protozoans – in drops of rainwater, and in 1683 he studied his own tooth scrapings and found bacteria, tiny moving beasts he named animalcules ('little animals').

Cells are generally transparent, making it difficult to discern their contents, even with improved microscopes. Van Leeuwenhoek is the first thought to have used cell 'stains', adding saffron to muscle cells to increase the contrast between cell components. Together Hooke and van Leeuwenhoek are credited with discovering cells, a feat which would have been impossible without their microscopes.

This artist's impression of a human cell shows organelles surrounded by cytoplasm and a membrane



## < IN A NUTSHELL

Harnessing the power of microscopes enabled scientists to explore a world invisible to the naked eye and discover that plants and animals are comprised of cells. Technological advances then meant we could learn how cells work.

## The life within

Humanity had found cells, but what were they? It was the discovery of their first component that would bring about a deeper understanding of their role, and what Hooke's dead cork cells had in common with van Leeuwenhoek's little animals.

Even though many others must have spotted it, it was the Scottish botanist Robert Brown who first named and described the cell nucleus – the control centre – in orchid cells in 1831. We now know that the nucleus contains the chromosomes of DNA and is the seat of power from which our genes regulate the rest of the cell.

A few years after Brown named the

nucleus, in 1837, the German scientist Theodor Schwann was having lunch with a fellow German researcher, the botanist Matthias Schleiden. Their conversation turned to the nucleus, which had so far been seen only in plants. Schleiden had observed that new plant cells seemed to come somehow from an existing nucleus. Schwann, who had been studying animal cells, remembered seeing structures that could well be nuclei.

Excited, the pair rushed to Schwann's laboratory to look at tadpole tissue. There were the nuclei: animals must be made of cells too. Both scientists wrote up their findings, with Schleiden describing cells

as the 'building blocks of life', and Schwann stating: "All living things are composed of cells and cell products." It may seem obvious now, but this 'cell theory' was revolutionary: all life from algae to aardvarks, bacteria to begonias, was made of cells.

The subsequent decades of the 19th Century, as microscopes improved, were fertile times for discovering the components of cells, and teasing apart the differences between the cells of animals, plants and bacteria.

Hooke, when coining the term cells, had technically discovered the cell wall in 1665. Human cells don't have a cell wall like plants and some bacteria, but they do have a cell

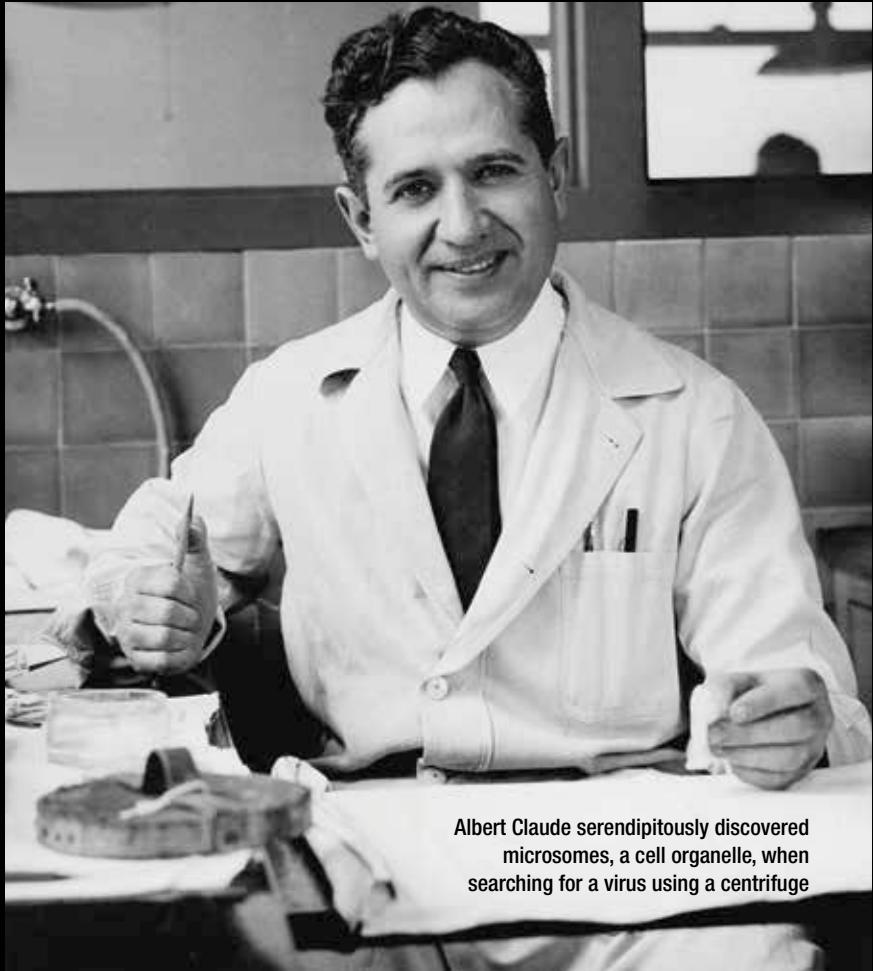
## THE KEY EXPERIMENT

Sometimes major scientific discoveries happen by chance, as Albert Claude found when he stumbled upon a key organelle while searching for a virus in the cells of a chicken

Much was known about the cell by the time that Albert Claude performed his key experiment of developing cell fractionation in 1930. But looking down a microscope was quite different to being able to separate out the parts of the cell to study them individually.

Claude developed cell fractionation while trying to isolate a virus, called Rous Sarcoma Virus, from chicken tumours. To do this he gently mashed up the tumour cells with a mortar and pestle (or sometimes a commercial meat grinder) to break the membranes and release the cell contents. He then put them in a tube and spun them in a centrifuge, the force of which speeds up the settling of heavier particles to the bottom of the tube. By successively spinning and extracting the sediment, the components of the cells are separated by size.

Claude found what he was looking for: a virus made of Ribonucleic acid (RNA). Good scientists run 'control' experiments too. In this case, Claude needed to show that the virus was present in only the tumour cells, and not healthy chicken cells. But when he repeated the process, he found that healthy cells also had similar RNA-rich particles in them. He named these mysterious organelles 'microsomes', discovering for the first time an organelle that researchers using a light microscope simply wouldn't have



Albert Claude serendipitously discovered microsomes, a cell organelle, when searching for a virus using a centrifuge

membrane, a layer of lipids (fatty molecules), proteins and other components. Though it was clear that something must surround animal cells, it wasn't until 1855 that the doctor Robert Remak found a way of hardening the membrane so he could see it clearly.

Seventy per cent of the volume of the cell is cytosol, a colourless liquid that is mostly water, plus salts and organic molecules. Together with components called organelles, cytosol makes up the cell's cytoplasm – everything in the cell membrane aside from the nucleus. Around 1835 the French biologist Félix Dujardin saw this 'life substance' in single-celled animals and named it sarcode (meaning 'the flesh of the cell').

In the mid-19th Century life was made a little easier for the nascent field of cell biology. Until this point a variety of natural dyes such as iodine, cochineal and van Leeuwenhoek's saffron had been used to stain cells. But in 1856, a young assistant chemist named William Perkin produced mauve, the first synthetic dye. Though not designed for cells, it was the first of many useful synthetic dyes.

### Internal organelles

Many cellular metabolic processes take place in the cytosol, but some occur in dedicated organelles. One of the best-known organelles is the mitochondrion, now known as the cell's 'powerhouse' because it produces a molecule that is used as a source of chemical energy. It's possible that mitochondria were first seen in muscle cells by the Swiss physiologist Albert von Kölliker in 1857. But it was Richard Altman, in Germany in 1894, who established that they were organelles and called them 'bioblasts'. They were renamed mitochondria by the German cell biologist Carl Benda in 1898.

Another organelle was discovered as a direct result of cell staining, and is also the only one to bear the name of its discoverer. In 1897 Camillo Golgi discovered an organelle called the Golgi apparatus in a makeshift lab he'd set up in a small hospital kitchen. It was there that he developed the 'black reaction' in which cells are impregnated with silver nitrate, highlighting their contents under the microscope. The Golgi appeared as a fine network inside the cell, and we now know that it is involved in the packaging up of proteins and lipids made by the cell.

As the 20th Century dawned, most of the

## CAST OF CHARACTERS

The great minds who harnessed cutting-edge technology of the time to explore cells



**ROBERT HOOKE**  
(1635-1703) contributed to fields as diverse as architecture, palaeontology and astronomy. He was an English researcher born in the Isle of Wight and known for his difficult manner and rivalry with fellow researcher Isaac Newton.



**ANTONIE VAN LEEUWENHOEK**  
(1632-1723) was a Dutch draper and amateur researcher. Son of a basket maker, he was an unlikely scientist, but his skill led to him producing some of the most advanced microscopes of his time, and the discovery of single-celled organisms.



**THEODOR SCHWANN**  
(1810-1882) was a German physiologist born in the town of Neuss. He was most productive early in his career, making discoveries in digestion, the nervous system and metabolism, before turning his attention to theology later in life.



**CAMILLO GOLGI**  
(1843-1926) was an Italian doctor and researcher. He concentrated his work on the nervous system though he also strayed into malaria research. Many of his discoveries are named after him, as is the village of his birth.



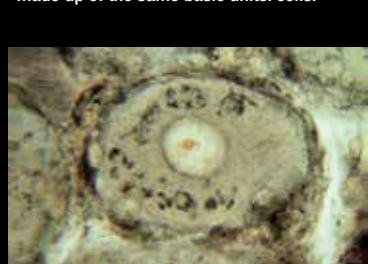
**ALBERT CLAUDE**  
(1899-1983) moved to the United States in 1929. He was a Belgian cell biologist who served for the British Intelligence Service during World War I, and was rewarded with a medical education in Belgium despite not having the required qualifications.

**TIMELINE**

**The advent of the microscope enabled biologists to explore the inner space of the human cell**

**1675**

Robert Hooke's *Micrographia* is published, in which he describes using a microscope to find boxy structures in a thin slice of cork and coins the term 'cell'.

**1665**

Antoine van Leeuwenhoek uses his powerful microscope (pictured) to discover 'little animals' — single-celled organisms — in rainwater, followed by bacteria from his own tooth scrapings in 1683.

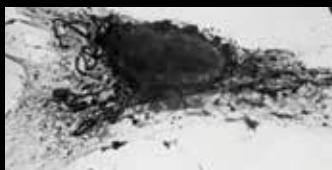
Matthias Schleiden and Theodor Schwann discuss the recent discovery of the nucleus and realise that both plants and animals must be made up of the same basic units: cells.

**1837****1897**

Camillo Golgi discovers the Golgi apparatus in nerve cells using the 'black reaction', his own staining technique which involves impregnating cells with silver nitrate (pictured).



Albert Claude develops the technique of cell fractionation in an attempt to isolate a chicken virus. He discovers ribosomes and isolates mitochondria in the process.

**1939**

Claude and colleagues produce the first electron microscope image of a cell (pictured), which George Palade describes as "cell biology's birth certificate".

**1945**

large components of the cell had been spotted and named. However, really getting to grips with what each part of the cell did was going to take more than looking. As the Belgian cell biologist Albert Claude said in his 1974 Nobel lecture: "Until 1930 or thereabout, biologists, in the situation of astronomers, were permitted to see the objects of their interest, but not to touch them; the cell was as distant from us as the stars and galaxies."

**Peering deeper**

At the same time, the tool that had been their window into cells — the light microscope — was coming to the end of its usefulness, unable to resolve objects smaller than the wavelength of light.

Two techniques developed in the first half of the 20th Century would come to the rescue, revealing structures invisible to the light microscope, confirming previous findings, and working out the biochemical role of organelles. The first of these, cell fractionation, allowed scientists to get their hands on cellular components. Developed in 1930 by Albert Claude at the Rockefeller Institute in the United States, it involved mashing up cells and then using the process of centrifugation to separate their subunits (see 'The key experiment', p80).

The second essential technique was electron microscopy, invented by German engineers in 1931. Physicists were already using the technology, but it was Claude who brought it into the realm of biology. Electron microscopy uses a beam of electrons as a source of illumination and can resolve much smaller objects than traditional microscopes because the wavelength of an electron is much shorter than that of a photon (a packet of light). In 1943 Claude began working with one of the few electron microscopes in the United States to look at subcellular particles produced by cell fractionation. In 1945, his lab was the first to use an electron microscope to image a whole cell. George Palade, who shared the Nobel Prize in 1974 with Claude and the Belgian researcher Christian de Duve, later called this image (see left) the "birth certificate" of cell biology.

Claude's lab was able to combine these techniques to determine what mitochondria do; they may have been observed and named in 1894, but it was only once they had been isolated that researchers could find out their function. He found that they contained many enzymes (proteins that act as catalysts)

## NEED TO KNOW

Key terms to help you understand the workings of cells

### 1 CELL

The basic unit of life — everything is made up of cells. Human cells have genetic material containing a nucleus and membrane-enclosed organelles, all in a watery substance called the cytosol and surrounded by a cell membrane.

### 2 EUKARYOTIC

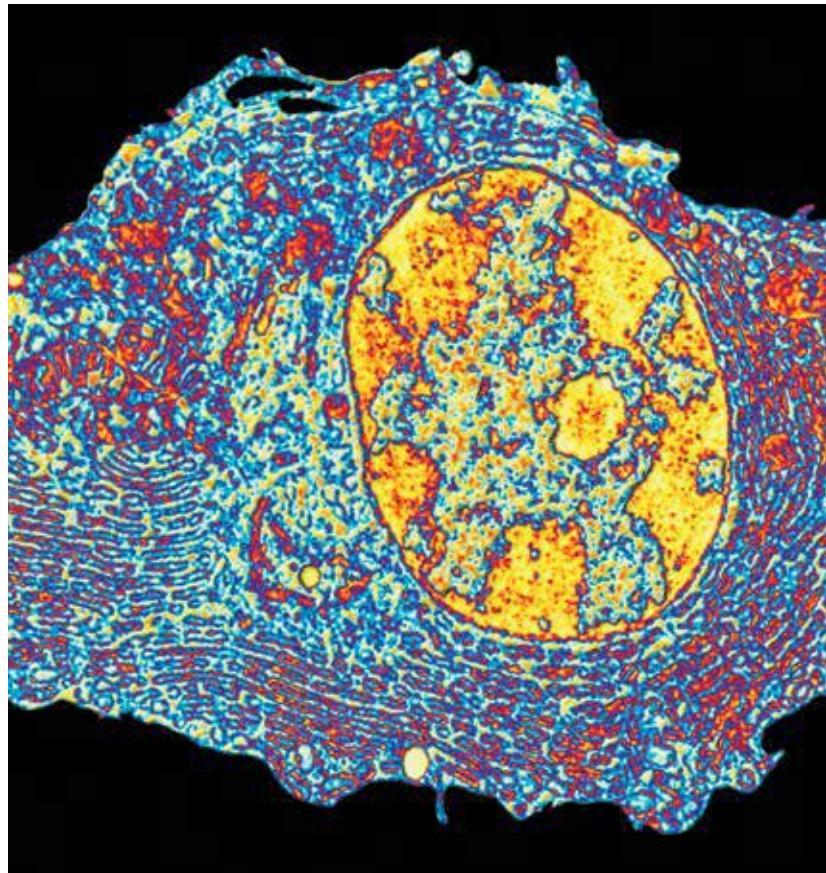
A type of cell which has a nucleus and membrane-enclosed organelles. Plant, animal and fungal cells are eukaryotic, as are some single-celled organisms.

### 3 ORGANELLE

A component of the cell that has its own specialised function, in much the same way that an organ plays a specific role in the body. They are often separated from the cell by their own membrane.

### 4 PROKARYOTIC

A type of cell with no nucleus, mitochondria or other membrane-enclosed organelles. Most prokaryotes are single-celled organisms, such as bacteria.



A cross-section of a human cell taken with an electron microscope reveals the nucleus (large oval centre) surrounded by cytoplasm. This is filled with the endoplasmic reticulum (ER) – seen as a pink network

associated with the chemical process of respiration, and that they are indeed the cellular power plants. He also used characteristic dyes to conclude that the organelles in his test tube were the same that had been seen under the microscope.

Also in 1945 Claude, along with colleague Keith Porter, used electron microscopy to discover the endoplasmic reticulum (ER), a large membranous system within the cell that is involved in producing proteins and lipids, and transporting them around the cell. The net-like structure had initially been spotted in 1902 by the Italian scientist Emilio Veratti, but the idea was discarded by the scientific community at the time.

In 1946, George Palade joined Claude's lab and began to refine many of his techniques. It was Palade who realised that the microsomes that Claude had discovered in his key experiment can be part of the ER. He renamed them ribosomes in 1955,

and found that they produce proteins. We now know that the membrane of the ER joins up with the outer membrane of the nucleus, providing a highway along which DNA is translated into proteins. Part of it, the 'rough' ER, has ribosomes attached, and another, the 'smooth' ER, produces lipids.

#### Waste disposal

Christian de Duve, a Belgian researcher born in England during World War I, took these new techniques further by discovering an organelle without using a microscope – he didn't even have one in his lab at the time. In 1949 de Duve discovered lysosomes – the waste disposal unit of the cell – by accident when researching insulin in rat liver cells. He used cell fractionation and then biochemical tests to determine that the cell's cytoplasm contains numerous lysosomes – membranous particles of enzymes playing a role in cell communication and energy metabolism, as well as breaking down

cellular components.

Researchers have discovered much more about the cell since the mid-20th century. But it's fair to say that today's cell biologists are more preoccupied with how the components work together than finding new ones. They tease apart the relationships between these cellular subunits – how they talk to each other to keep the delicate equilibrium of the cell's workings in check; how they behave in certain circumstances, and how this knowledge can be exploited to develop drugs and other treatments.

It is now possible to watch living cells go about their business, using the modern versions of van Leeuwenhoek's saffron to watch specific parts of the cell in action. Today's image of the cell is dynamic – a high-definition film to the 17th century's hand-drawn sketch. ☺

**Katherine Nightingale** is a science writer with a degree in molecular biology.

# PUZZLE PIT

SEND IN YOUR ENTRIES  
AND  
WIN EXCITING PRIZES

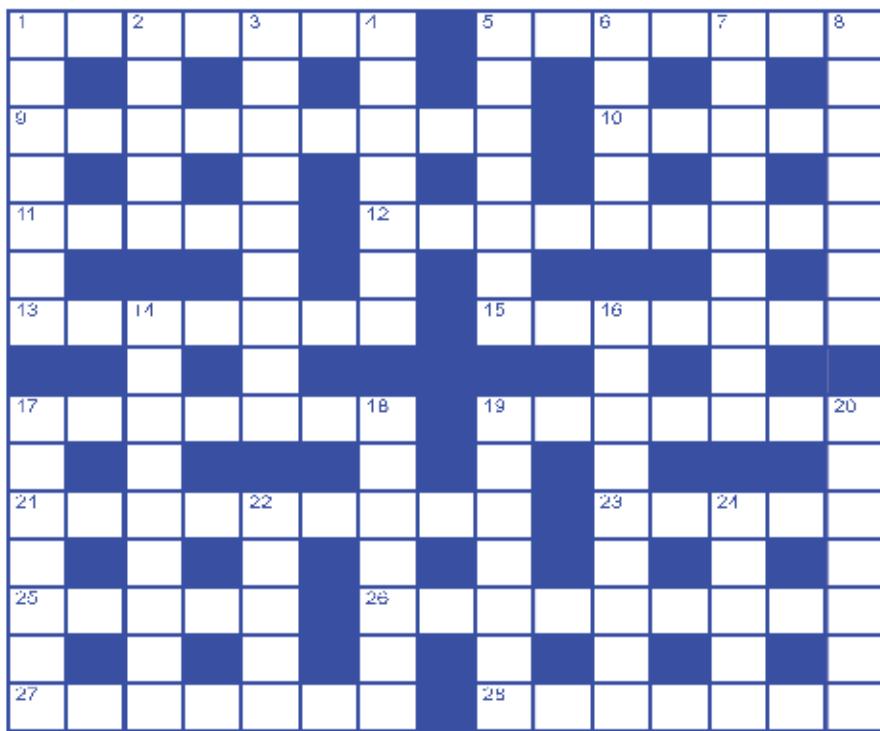
## CROSSWORD NO.27

### ACROSS

- 1 Turn or become pale with fear or trepidation (2,5)
- 5 2014-15 FA Cup Champions (7)
- 9 The "Maid of Orleans" (4,2,3)
- 10 Recently or very lately (5)
- 11 A chief officer or magistrate of old (5)
- 12 Of great consequence (9)
- 13 Tropical cyclone; hurricane (7)
- 15 Austere or rigorous like the old Greek? (7)
- 17 Associates, compares or likens (7)
- 19 \_\_\_ ahead of : very much superior to? (7)
- 21 Italian restaurant (9)
- 23 Russian President Vladimir \_\_\_ (3,2)
- 25 African antelope (5)
- 26 Banish; exclude by general consent (9)
- 27 \_\_\_ on to : attaches oneself to; understands? (7)
- 28 Chooses before others (7)

### DOWN

- 1 Surat's state (7)
- 2 Marine mammal, Moby Dick for one? (5)
- 3 Removed wrinkles; smoothed (6,3)
- 4 Euphoria (7)
- 5 Concedes or assents to (7)
- 6 Less mad, more rational (5)
- 7 Carry coals to \_\_\_\_ (9)
- 8 Exaggerate in one's speech or action? (3,2,2)
- 14 Tear asunder? (4,5)
- 16 An aircraft (9)
- 17 Of the back of the eye (7)
- 18 Solemn; not light-hearted (7)
- 19 Commence operation (5,2)
- 20 Those who lapse against moral laws (7)
- 22 Tutor or educate (5)
- 24 Clan (5)



### YOUR DETAILS

NAME: \_\_\_\_\_

AGE: \_\_\_\_\_

ADDRESS: \_\_\_\_\_  
\_\_\_\_\_

PINCODE: \_\_\_\_\_

TEL: \_\_\_\_\_ MOBILE: \_\_\_\_\_

SCHOOL/INSTITUTION/OCCUPATION: \_\_\_\_\_  
\_\_\_\_\_

EMAIL: \_\_\_\_\_  
\_\_\_\_\_

### How to enter for the crossword

**crossword:** Post your entries to BBC Knowledge Editorial, Crossword No.27 Worldwide Media, The Times of India Bldg, 4th floor, Dr Dadabhai Navroji Road, Mumbai 400001 or email bbcknowledge@www.co.in by 10 August 2015.

Entrants must supply their name, address and phone number.

**How it's done:** The puzzle will be familiar to crossword enthusiasts already, although the British style may be unusual as crossword grids vary in appearance from

country to country. Novices should note that the idea is to fill the white squares with letters to make words determined by the sometimes cryptic clues to the right. The numbers after each clue tell you how many letters are in the answer. All spellings are UK. Good luck!

**Terms and conditions:** Only residents of India are eligible to participate. Employees of Bennett Coleman & Co. Ltd. are not eligible to participate. The winners will be selected in a lucky draw. The decision of the judges will be final.

### WINNERS FOR CROSSWORD NO. 26

Devpriya, Haryana

•

Sayan Maji, Kolkata

•

Manu Nicholas Jacob, Bengaluru

### SOLUTION OF CROSSWORD NO. 26



## Q1 PICTURE SEARCH

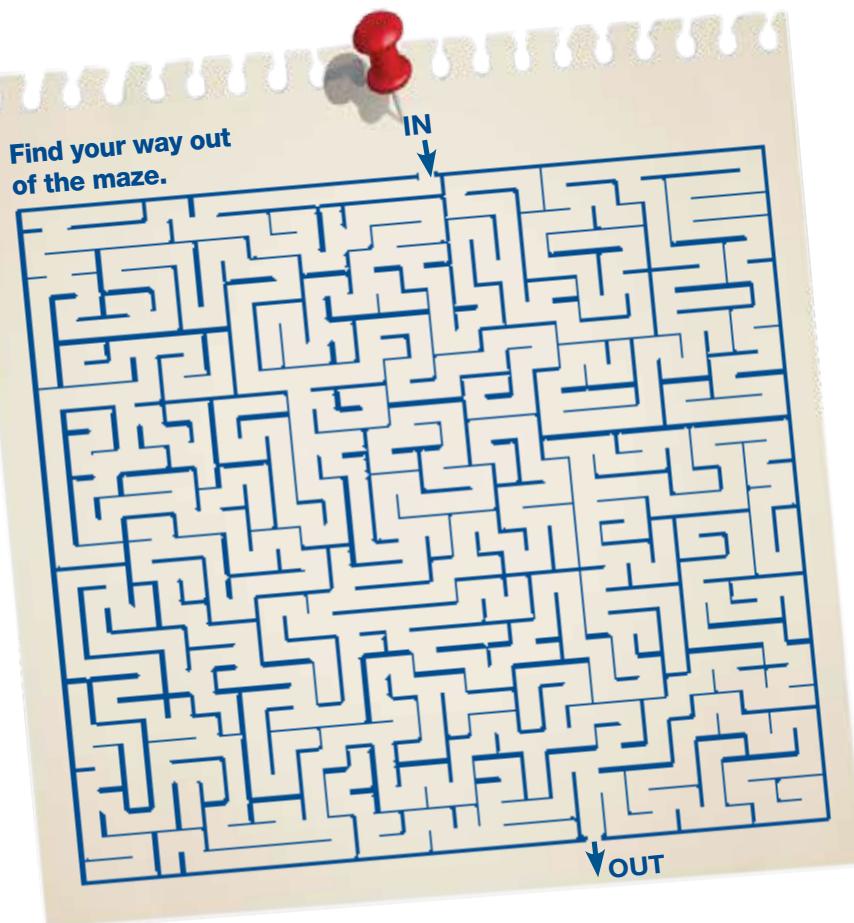
In the jumble below, the words represented by each of the 16 pictures are hidden either horizontally, vertically or diagonally forward or backwards but always in a straight line. See how many of them you can find? Look out for descriptive names.



## Q2 HEAD AND TAIL

Look at the clue to solve the answer in the form of a compound word. The second part of the next answer is the first part of the next answer.

Pink flower	Sweet		
Legendary archer			
Reveal everything			
Safe			
Free from uncertainty			
— to size			
Reason to write a check		Payment	



## Q3 SCRAMBLE

Solve the four anagrams and move one letter to each square to form four ordinary words. Now arrange the letters marked with an asterisk (\*) to form the answer to the riddle or to fill in the missing words as indicated.

ROMAN	*		*	*
GOILO	*		*	*
ALOPDU	*			*
LOUYBD	*		*	*

If opportunity doesn't knock \_\_\_\_\_ —  
Milton Berle (5,1,4)



# MINDGAMES

Test your knowledge with our Big Quiz set by James Lloyd

MONTEREY BAY AQUARIUM/RANDY WILDERS, DONNA BEER STOLZ/UNIVERSITY OF PITTSBURGH, WELLCOME LIBRARY LONDON

**1** What name has British astronaut Tim Peake given to his upcoming six-month mission aboard the International Space Station?  
 a) Corpuscle  
 b) Principia  
 c) Newton

**2** Complete the recent headline:  
 "\_\_\_\_\_ of exercise can transform health"  
 a) Six seconds  
 b) Six minutes  
 c) Six hours

**3** In August, Rosetta became the first spacecraft to rendezvous with a comet. But when was the spacecraft launched?  
 a) March 2004  
 b) March 2009  
 c) March 2014

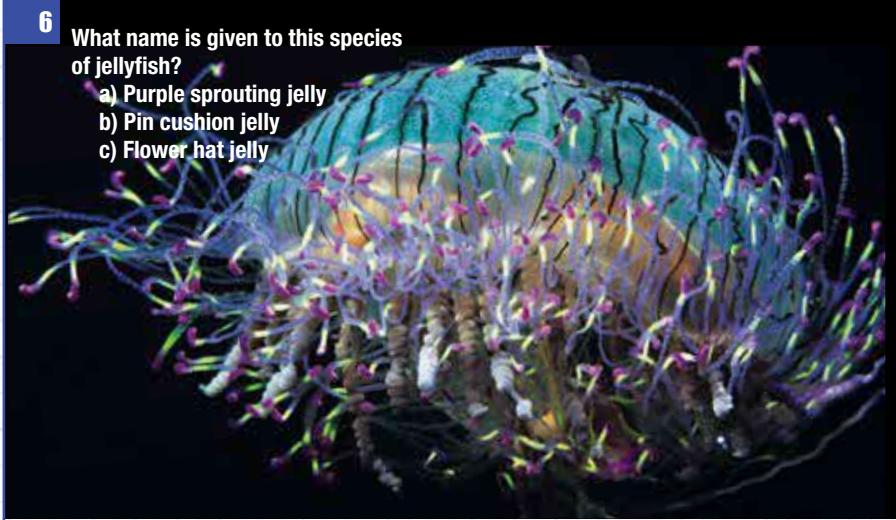
**4** According to scientists at Aberystwyth University, what's the most hygienic way to greet a friend?  
 a) Shaking hands  
 b) A high five  
 c) Fist-bumping

**5** This 19th Century wood engraving shows two men enjoying laughing gas. What's the scientific name for this substance?  
 a) Ethylene dioxide  
 b) Carbon monoxide  
 c) Nitrous oxide



Recreational use of laughing gas isn't a new phenomenon

**6** What name is given to this species of jellyfish?  
 a) Purple sprouting jelly  
 b) Pin cushion jelly  
 c) Flower hat jelly



**7** In July, Russia's space agency lost, and then regained control of, a satellite carrying what payload?  
 a) Mice, bonsai trees and honey bees  
 b) Geckos, mushrooms and fruit flies  
 c) Ferrets, watercress and fire ants

**8** Researchers in the US have observed the longest brooding time ever seen in the natural world. What creature was spotted guarding its eggs for over four years?  
 a) Emperor penguin  
 b) Deep-sea octopus  
 c) Leatherback sea turtle

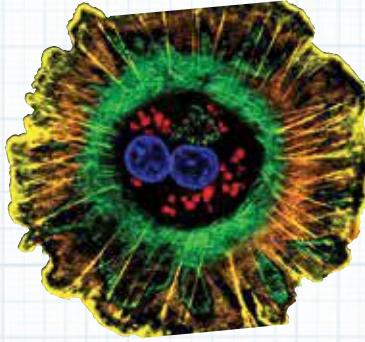
**9** Complete the recent headline:  
 "Mathematical equation can predict your \_\_\_\_\_"  
 a) Fitness  
 b) Happiness  
 c) Wealth

**10** A Spanish physicist has invented an ice cream that performs what feat?  
 a) It stays frozen in sunlight  
 b) It reacts with saliva to create a fizzing sensation on your tongue  
 c) It changes colour

**11** A nine-year-old boy has had what replacement body part created from his ribs at London's Great Ormond Street Hospital?  
 a) His ears  
 b) His fingers  
 c) His nose

**12** Earlier this year, Lego released a set that, for the first time, included three female scientists. Which of these figures wasn't featured?  
 a) An astronomer  
 b) A biologist  
 c) A palaeontologist

**13** What's shown in the image below?  
 a) A human liver cell  
 b) A computer simulation of the Big Bang  
 c) A cross-section of a plant stem



**4 Mindgames:** 1b, 2a, 3a, 4c, 5c, 6c, 7b, 8b, 9b, 10c, 11a, 12b, 13a.

**5 Answer:** Words: Manor, igloo, piano, double Millot - Beret - Sweet William - Tell - Ali - Clear - Cut - Down - Pyramid.

**6 Head & Tail:** Sweat - William - Tell - Ali - Clear - Cut - Down - Pyramid.

**7 Picture Search:** Almond, banana, barbecue, camel, ships, spoon, stapler, cards, coin, hen, jacket, Jupiter, key, knot, mango, ruby,

**SOLUTIONS:**

# EDU TALK

**Corey Stixrud, Principal of Kodaikanal International School speaks about how a blend of theory and practical learning is an intrinsic part of the school's 115-year legacy**

**Can you tell us about *Design'94* and what it stands for?**

*Design'94* is a document that outlines the core of our identity—our guiding principles as an educational institution. It is a statement of who we are, and it is a statement of intent—our vision as a leading international school in India for the 21st Century. This document asserts that we are both a multicultural school and a Christian institution; that our students go on to pursue higher learning in colleges and universities across the world; that we are inclusive and broad-minded in that we welcome and learn from students and staff from all faiths and cultures; and that we derive our identity both as an international school but also as a school in the context of our south Indian setting.

**KIS was the first IB school in the country. Now, there are quite a few IB schools in India. What sets KIS apart from them?**

We became the first IB school in India and the third IB school in Asia forty years ago, in 1975. We joined the IB family because it was a good fit with our identity and our ideals, not because it was the latest curricular rage, which is certainly the trend right now across India. Because of our heritage as an American school, and because we are a 115-year-old institution, our approach to education is different from most any other international or IB school in India. I could cite many ways that sets KIS apart, including our facilities and our unique setting in Kodaikanal, but one definite advantage is our worldwide network of alumni who love and support the school. When you join KIS you are joining a strong community that spans both continents and generations.

**What according to you is good education?**

Ultimately, good education involves instilling an attitude of learning and thinking that lasts a lifetime. This means that our approach at



KIS is student centered and holistic. Learning here is not a passive endeavour that ends at exam time; our students are actively and creatively engaged in their own intellectual and social development. Our objectives do not revolve solely around test scores but rather on educating thoughtful, caring young people who can assert themselves with independence and confidence in a globalised world.

**How are students of KIS equipped to handle real world challenges?**

Young people today, while more informed in general (because of technology and because the world is “smaller”), also tend to be more shielded from real-world interaction. I think one of our strengths in this regard is our ability to provide students with authentic learning opportunities in the form of field trips, international exchanges, and through a

programme we call Social and Environmental Experience, a requirement for our students that ensures their involvement in real-world issues that face the local community. We also emphasize critical thinking, communication, and collaborative skills at KIS such that our students are equipped to tackle the complex challenges that life will inevitably throw their way.

**What vision do you see for students of KIS after they graduate?**

At our recent Grade 12 graduation ceremony, I told our graduates that, in my experience, KIS alumni have a set of skills that set them apart. They are confident, social, assertive, and caring individuals who can have a positive impact on the world. I’m also fond of reminding our students that the world needs them—it needs the skills, attitudes, and knowledge that they receive at KIS. This is our vision, to be a school that the world needs, and I’ve met enough accomplished and successful KIS graduates in all walks of life to be assured that we are on the right track.

**Learning is relational, and I like to say that our teachers don't teach subjects as much as they teach individuals.**

- Edited by Moshita Prajapati

# TECH HUB



## ON THE HORIZON

### 5G

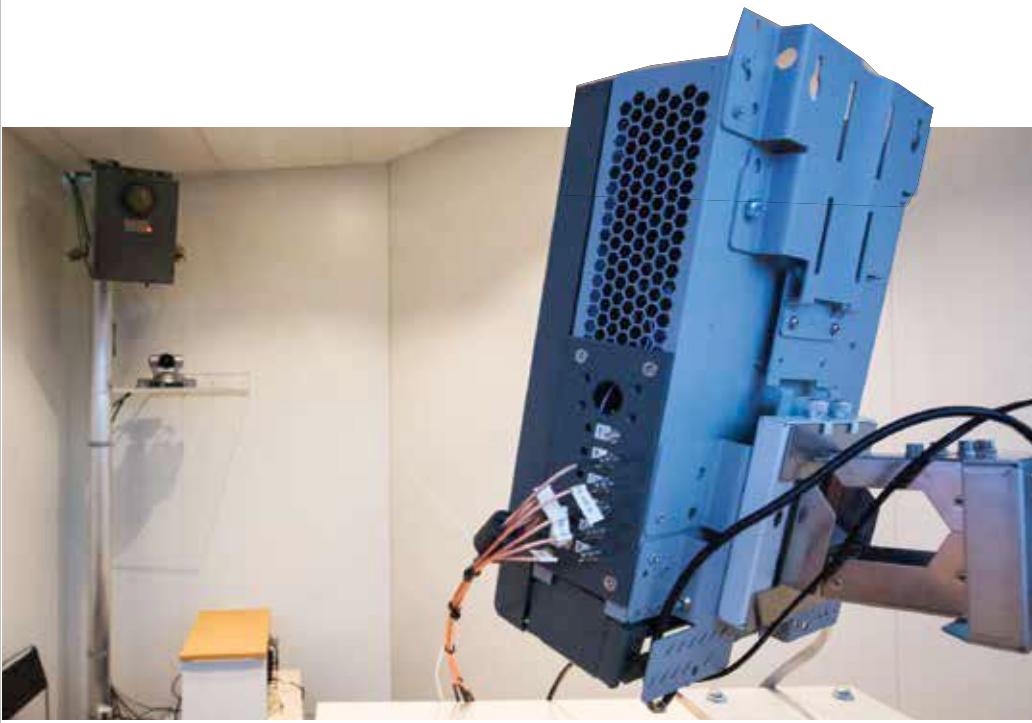
The next-generation mobile phone network is coming

**C**hances are, if you've recently upgraded your phone, you'll have graduated from a 3G network to the faster, newer 4G technology. Films download in minutes, TV shows stream live and Facebook loads up in the blink of an eye. It's like using home broadband wherever you go, so we thought there'd be little need for another newer, faster technology, but we were wrong. The mobile network is about to explode.

Not literally, of course. But the number of

nodes on our mobile network – that is, the number of connected devices – is about to expand rapidly. A few years ago, it was just our smartphones that needed data on the go, but now a whole new species of gadgets ultimate test There are already internet-connected cars, cameras and smartwatches that need their own SIM cards to function. Pile on advances like autonomous cars, intelligent traffic networks and homes stuffed with washing machines,

►



fridges and cookers that can talk to your phone (collectively termed the Internet of Things) and you can see how our mobile networks might struggle in years to come. In fact, market analysts at Gartner predict that the number of networked devices will skyrocket from five billion in 2015 to 25 billion by 2020.

Fortunately, a solution might already be on its way. Several universities and companies are racing to build a new network standard by 2020 – just in time for the Tokyo Olympics – that will support the Internet of Things. One of the furthest ahead is Nokia, which is running real-world tests in Finland right now, reaching speeds of up to 10Gbps, 10 times faster than the fastest recorded 4G connections. To reach these figures, Nokia has had to reinvent how phone masts connect to our devices.

The solution lies in unused bandwidths. Currently, our mobile phones receive relatively large signals – low frequency radio waves, tens of centimetres long, that are less vulnerable to interference. But these frequencies are in high demand, so bandwidth is limited, and 4G already takes how much data we can squeeze into these waves to the limit. But elsewhere in the radio spectrum there's plenty of room – so the people that build communications networks are starting to look elsewhere. In particular, they've begun testing

higher-frequency waves. Until now these small 'millimetre' waves didn't work very well: they tended to lose more energy over long distances, and struggled to penetrate solid materials. And because they can be scattered by fog, rain and foliage, they require more power to send and receive data reliably.

That's where Nokia's technology comes in. It's tried to remedy millimetre waves' flaws in three ways. First, the network will set up several radio connections with your phone at once, so that data can be channelled back and forth through several streams simultaneously. Second, the antennae will use special arrays to focus and strengthen the beam sent to your phone. Finally, the network will use smaller 'cells', with smaller base stations that will disperse and reroute signals from mobile masts straight to your phone.

But this isn't the only solution. And if speed is the measure of success, then researchers at the University of Surrey's 5G Innovation Centre are way out in front. Its lab tests recorded speeds of up to 1 terabit per second (1Tbps), a speed 100 times faster than Nokia's test, though not much else is known yet about the technology involved.

Whichever method wins out, 5G is on its way. It can't come soon enough to cope with all the devices that will be online. ☺

**Daniel Bennett** is the reviews editor at *BBC Focus Magazine*.

# TECHOMETER

## WHAT'S HOT

### GRAPHENE

The 'miracle material' has yet to deliver many miracles to the general public, but they could be just around the corner. At the opening of the UK's National Graphene Institute in Manchester, the material's inventor showed off the world's first graphene product: a light bulb. It'll cut energy use by 10 per cent and last much longer than current energy-savers. Well, it's a start, isn't it?



## WHAT'S NOT

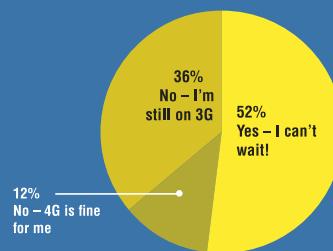
### ONLIVE

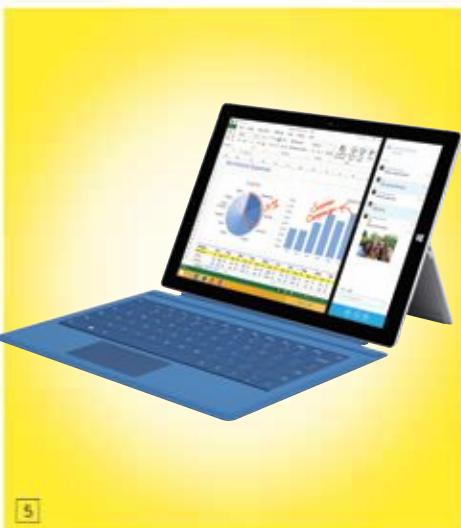
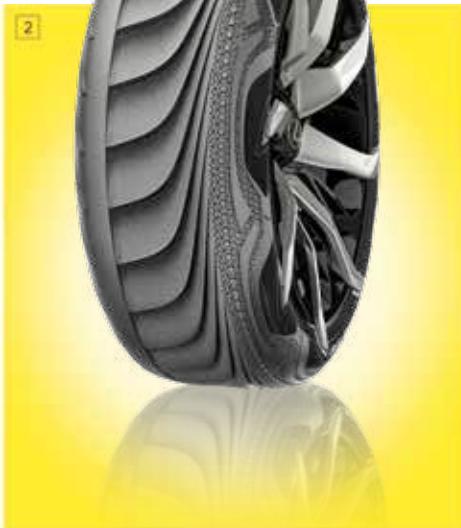
OnLive, a game streaming service is closing down. You could connect to OnLive's servers via PC, tablet or its own console, and play blockbuster videogames on its computers while you controlled the action from your own screen. This meant that you didn't need expensive hardware to enjoy the latest games. Now, Sony has bought the company – along with 140 patents that will help improve its own streaming service.



## READER POLL

Are you excited about 5G?





## APPLIANCES OF SCIENCE

### 1 YOU CAN STICK IT

Intel has squeezed an entire PC into this chocolate bar-sized device. To get Windows up and running, you slot the Compute Stick into your TV's hdMI slot, plug it in at the mains, then simply connect a mouse and keyboard via Bluetooth. With 32GB of storage and 2GB of rAM, it's powerful enough to handle most everyday tasks and even has a USB slot for plugging in any media. The best bit, though, is the price!

**Intel Compute Stick \$149 (£100), intel.co.uk**

### 2 TYRED OUT

As you munch through the miles on the motorway, there's tonnes of energy going to waste. The friction between your tyres and the tarmac generates a lot of heat, for example. So Goodyear's prototype tyre harvests this heat and converts it into electricity to charge a battery-powered car. Even stood still, black patches on the rubber will absorb sunlight and give you a few extra miles on the clock.

**Goodyear BH03 Price TBC, goodyear.com**

### 3 BEATS FOR BONEHEADS

Everyone knows how unsettling it is when you hear a recording of your own voice. That's because what we're actually used to hearing isn't our voice in the air, it's the sound waves travelling to our inner ear through our bones. These bone conduction 'headbones' deliver sound to your inner ear in much the same way, so that you can leave your ears unplugged and still be able to hear the outside world.

**Damson Audio Headphones £99, damsonaudio.com**

### 4 FEELING BLUE

Solar power, fr power and man power can all be used to charge your phone – and now you can add water power to that list. The Blue freedom is a personal hydroelectric power station made to charge your gadgets from flowing water. You just drop the turbine into the blue and secure the power station to the ground. One hour in the water will give your phone a whopping 10 hours of power.

**Blue Freedom \$319 (£213), blue-freedom.net**

### 5 TABLET TRANSFORMER

It looks like a tablet, but what you're actually looking at is a full-fledged PC. As well as doing all the things you'd expect a tablet to do, the Surface will work as your home computer, thanks to a new, more powerful processor that will run the majority of Windows software, where previous models often struggled. With the optional keyboard/touchpad dock, it'll be as deft as a laptop at more complex tasks, too.

**Microsoft Surface 3 £419.99, microsoft.com**

### 6 WAKEY-WAKEY!

Never sleep in again! The Wake smart alarm sits over your bed, and when it's time to get up the device's body heat sensors seek you out. Once it's got a lock-on, the alarm uses a parametric speaker to send ultrasound waves direct to your location – your partner won't feel a thing – and shines a focused light at your head. There's no snooze button: the alarm will only turn off when it sees you've left the bed.

**Wake smart alarm \$199 (£134), luceralabs.com**

# GAMES REVIEW

## Heroes of the Storm



PC/Mac OS : Free

**H**e Multiplayer Online Battle Arena (MOBA) genre is quickly becoming the most popular and lucrative genre in competitive gaming. Developed by Blizzard, *Heroes of the Storm* (*HoS*) is the latest offering in this genre, albeit one less intricate and demanding than its peers.

The game sticks to the traditional five-versus-five format of other MOBAs, but differs in many other aspects. Firstly, the games do not all occur on the same standard map, allowing players to test their skills in different environments. Secondly, individual skills do not count for as much in *HoS*, as all the players in a team can only level up together, after they have reached a collective threshold of experience points. Also, the presence of ancillary quests that players can complete to impact the outcome of the game and the ability to recruit Non Playable Characters as mercenaries brings a fresh dimension to the pace of the action. It's

these differences that contribute to making *HoS* a more beginner-friendly game than the more popular *DOTA 2* and *League of Legends*.

As with most MOBAs, players select their Hero from a roster of characters, and fans of Blizzard will be delighted with the choices. The Heroes in the game are some of the most iconic characters from Blizzard's most epic franchises, including *Diablo*, *Starcraft* and *World of Warcraft*. *HoS* employs a shuffling roster system, which means the list of Heroes available changes regularly. Also present is Blizzard's famous brand of humour, with the characters spouting one-liners and pop culture references through the game.

It is the perfect starting point for somebody who wants to explore MOBA games, but isn't ready to tackle the steep learning curve associated with the genre. While it won't be able to knock *DOTA 2* off the #1 MOBA perch, *HoS*'s certainly an entertaining diversion.

## FINGER ON THE BUTTON

### FREE DLC WITH HALO 5

If you weren't already, here's another reason to look forward to *Halo 5* in October this year. The developers, Studio 343, recently announced that the game would feature the greatest emphasis on multiplayer mode in the franchise yet. The game will ship with 20 multiplayer maps, with another 15 being available as free DLC.



### OCULUS ANNOUNCES XBOX PARTNERSHIP

While we wait for the Oculus Rift to make Virtual Reality (VR) accessible, the anticipation just grew as they announced a partnership with Microsoft and Xbox. This means that not only will the Oculus Rift be compatible with both PCs and Xboxes, but the VR headset will also ship out with a wireless Xbox controller.



### SHADOW OF MORDOR SPECIAL EDITION AVAILABLE NOW

The critically acclaimed RPG adventure from 2014, *Middle Earth: Shadow of Mordor*, announced that it will release a Game of the Year edition in India. Made for the PS4 and Xbox One, the game will cost ₹2,499 and contains all the DLC that was missing from the original edition.



- Dushyant Shekhwat

# GADGETS



## POLAROID ZIP

Back in the day, the Polaroid instant camera made clicking photos fun thanks to its instant printing. Today, the company repackages the joy of instant printing for the smartphone generation. The Polaroid ZIP is a convenient pocket-sized device that connects with your phone and can print photos in less than 60 seconds with no hassles over ink, toner and cartridges. It uses patented ZINK Photo Paper, which come with sticky backs to allow you to instantly stick them up wherever you please.

Price: ₹8,291 | [www.polaroid.com/zip-instant](http://www.polaroid.com/zip-instant)



## 360FLY

The panorama mode on your iPhone is officially passé. Enter the 360Fly, the camera that finally allows you to record literally all around you. With 360 degree recording, the videos and images from the 360Fly are interactive, allowing viewers to swipe and scroll, shifting the edges of the frame to continually reveal more of the picture. The durable design is resistant to rain, dust and drops, making this the perfect companion for your next outdoor adventure.

Price: ₹31,826 | [www.360fly.com](http://www.360fly.com)



## HERE ACTIVE LISTENING SYSTEM

What if we had the power to tune out a boring sermon or to eliminate background noise as our favourite songs played? With Here Active Listening System, those dreams can be a reality. Developed by Doppler Labs, this piece of technology consists of two in-ear earplugs and a companion smartphone app. The app allows users to apply equaliser settings and control the volume of sounds reaching their ears, as well as enabling them to enhance the sound quality by adding effects such as reverb and crackle. Pre-set filters allow you to programme your auditory environment to your liking on the go.

Price: ₹15,930 | [www.dopplerlabs.com](http://www.dopplerlabs.com)



## MELLOW BOARD

Billed as 'the endless ride', the Mellow Board aims to bring effortless locomotion to skateboarders. Despite its name, the Mellow Board isn't actually a board, but a motor with wheels that can be attached to the base of a board in lieu of front wheels. This lightweight motor has four different riding modes and can reach top speeds of up to 40 km/h. Compatible with older skateboard models, the Mellow Board is the perfect addition to any board enthusiast's collection!

Price: TBA | [www.mellowboards.com](http://www.mellowboards.com)



## PHREE SMARTPEN

Imagine you're searching for a piece of paper to take notes for work, but you can't find any. Suddenly, your phone rings and you press a button on the pen you're holding, lift it to your ear and begin chatting away, while the pen takes your notes for you! That's the experience the Phree Smartpen promises. The paper-free pen writes on any surface thanks to a 3D laser inferometer that tracks the nib's movement, relaying your scribbles to a connected device instantaneously.

Price: TBA | [www.otmtech.com](http://www.otmtech.com)



## LILY CAMERA

This drone has a mind of its own. To record a video, just power it on and toss it into the air. The rotors will come to life and the drone will remain airborne, following you around and filming as it goes. Lily pairs with a circular remote, which it is programmed to follow the remote anywhere. It takes stunning high quality photos and is durable enough to even survive a landing in water.

Price: ₹31,826 | [www.lily.camera](http://www.lily.camera)



## NAVDY

Navdy is a gesture-controlled user interface for vehicle navigation. A transparent Heads-Up Display (HUD) projects GPS information, call alerts and notifications as if it's floating six feet ahead of the car. The fact that it pairs with both Android and iOS devices and is reverse compatible with any car model makes the deal even sweeter.

Price: ₹19,070 | [www.navdy.com](http://www.navdy.com)

# INSIDE THE PAGES

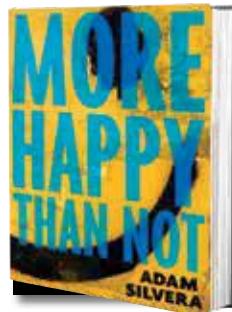
## ON THE SHELF

OUR RECOMMENDATIONS FROM THE YOUNG ADULTS GENRE

### MORE HAPPY THAN NOT

by Adam Silvera

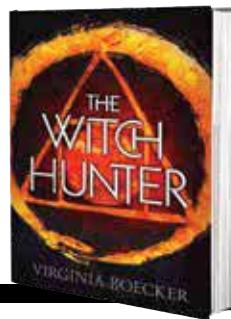
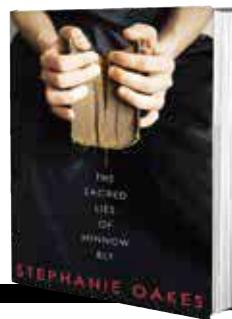
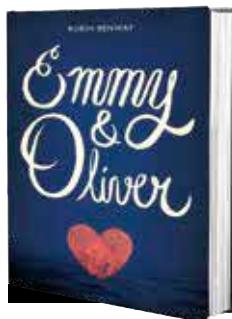
This is a touching tale of a young boy named Aaron, who doesn't have a lot going for him. He has grown up in poverty and his family and friends have been there for him. But that boat is rocked when Thomas enters his life. Thomas introduces Aaron to a world of happiness, but when Thomas rejects Aaron's feelings for him, he turns to Leteo Institute's memory-altering experimental surgery to 'straighten' himself, even if it means forgetting who he is. A powerful heart-wrenching tale about acceptance, this book is sure to make you reach for the tissues.



### FINDING AUDREY

by Sophie Kinsella

From the devastatingly witty and imaginative mind of Sophie Kinsella comes a book that is cute and poignant in its portrayal of people suffering from anxiety attacks. 14-year old Audrey suffers from anxiety disorder and it doesn't help that her family is crazy to the boot. Her sessions with Dr Sarah have improved her interactions with people tremendously but when she meets Linus, she is engaged with her calm self. Their friendship deepens into a love that not only helps Audrey, but also her family.



### EMMY & OLIVER

by Robin Benway

Emmy and Oliver were thick as thieves. But that was 10 years ago, before Oliver was kidnapped. And since then, Emmy's life has been on a lockdown – no parties and definitely no night surfing. Then one day, just as he had disappeared, Oliver returns and Emmy is overjoyed to have her best friend back. But Oliver is harbouring a dark secret that may just sever his friendship and burgeoning love for Emmy. Full of romance, coming-of-age emotion, and heartache, these two equally compelling characters create an unforgettable story.

### THE SACRED LIVES OF MINNOW BLY

by Stephanie Oakes

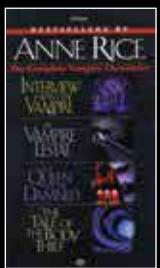
Minnow Bly has the chance to live her life. Again. And this time with her own rules. Inducted into the Kevinian cult 12 years ago, Minnow has learned to measure her words – it was speaking without thinking that got her hand cut by a cult member. The Prophet of her cult is murdered and she along with others are rescued and placed in juvenile detention. As she struggles with her newfound freedom in a cell, she muses over her decision whether to tell the police about her past and secure her future or must she forsake her future to protect her past?

### THE WITCH HUNTER

by Virginia Boecker

Elizabeth is a witch hunter. In fact, she's the best across the realms. So when she is accused of being a witch, she is gob smacked. Before her enemies can capture her and burn her to the stake, help comes to her in the form of Nicholas Perevil, the most dangerous and evil wizard in the kingdom. He will help her if she helps him in finding a cure for the curse he has been inflicted with. Thrust into the magical world of witches, ghosts, pirates and a handsome healer, Elizabeth finds out that sometimes right is wrong and wrong is right and no course to success runs smooth. The first in the series, this fantasy themed fast paced thriller fiction is bound to keep you tied to the book, without any magic of course.

**From downright evil to surprisingly saintly, these books capture the 'lively' personalities of vampires in literary fiction**

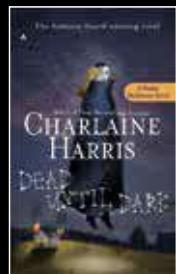


## THE VAMPIRE CHRONICLES

BY ANNE RICE

The series is a cultural touchstone when it comes to the vampire literature canon. Rice's vampire Lestat, the protagonist of the series, does not fear garlic, crucifixes, holy

water, or silver. Even wooden stakes are only a danger to him if the sun comes up while he is struggling to get free. Over twelve novels, Rice weaves a tale of the aristocrat French nobleman in the 18th Century living the decadent and thrill-filled life of a vampire while trying to stay a step ahead of his enemies – humans and vampires as he continues to search through the centuries to find others like him.

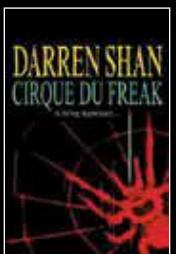


## THE SOUTHERN VAMPIRE MYSTERIES

BY CHARLAINE HARRIS

The invention of the synthetic blood, Tru Blood, allows vampires to reveal their existence to humans. Sookie, a telepath waitress in the

fictional town of Bon Temps Louisiana meets Bill Compton, a vampire whom she saves from blood drainers. Sookie's life then takes a supernatural turn when she is introduced to vampires and becomes their conduit while dealing with humans. Her 'job' includes reading the minds of humans, werewolves and even fairies and before you know it, she is so knee-deep into vampire politics that she is duped into marrying Eric Northman, the vampire Sheriff to protect her life from vampires who want her dead. In case you are thinking why the names sound so familiar, the popular TV show True Blood is adapted from the book series.



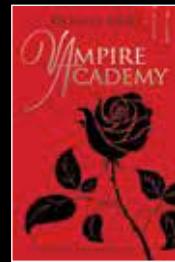
## THE SAGA OF DARREN SHAN

BY DARREN SHAN

This 12-part series begins when Darren along with his best friend Steve visits an illegal freak show in their town. Fascinated by spiders since a young age, Darren hastily

hatches a plan to steal Madam Octa, a highly poisonous spider belonging to Mr Crespely

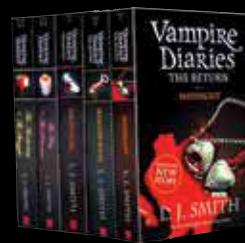
after watching their act. Unbeknownst to him, Mr Crespely is actually a vampire! What follows is a series of unfortunate events that force Darren into approaching Mr Crespely to turn him into a vampire. The series trails his struggles as he fumbles his way into finding a strong foothold in the hidden and often treacherous world of vampires.



## VAMPIRE ACADEMY

BY RICHELLE MEAD

Vampires come to a high school. Literally. 17-year old Rosie is training to be a bodyguard for her friend Lissa, a royal monarch. Lissa by the way happens to be a vampire and Rosie is the union of a vampire and a human aka dhampir. They both enroll at Vampire Academy, where apart from juggling studies, mean girls and boys, Rosie and Lissa also have to have their wits about to outsmart their common enemy – the Strigoi – evil undead vampires who want to abolish the monarchy. Yes, high school got a tinge more exciting and dangerous.



## THE VAMPIRE DIARIES

BY L J SMITH

The series is centered around the complicated and tumultuous relationship

between Elena Gilbert, the protagonists and the two Salvatore brothers Damon and Stefan who are vampires and happen to be in love with her. Elena's malicious doppelgänger Katherine, who converted the boys, returns in their life interrupting the high school romance thankfully. Elena's friend Bonnie is revealed to be a witch and she joins forces with Elena and the brothers as they battle the evil Original Vampires and Katherine from destroying the town of Mystic Falls once again.

**DID HE SAY THAT!?**  
*"I try to create sympathy for my characters, then turn the monsters loose"*  
 - Stephen King

## QUESTION OF THE MONTH

**Favourite Comic Character?**



My favourite comic character is the Wolverine from the

Marvel comics. I love him for many reasons but most for his imperfections. He taught me that it is not the size of the dog in the fight but the size of the fight in the dog that matters. That's what keeps me going when I feel low or incapable of doing something. I would like to thank his creator Stan Lee for creating a person who gives me endless inspiration without even existing!

- M.R. Vishwavaasu Aprameya,  
Hyderabad

## READER REVIEW

**Capturing Wildlife Moments in India**  
 by Ashok Mahindra

This is an information treat since the author who is an avid traveler, photographer & geologist has been known for his passion to bring out the best in his books.

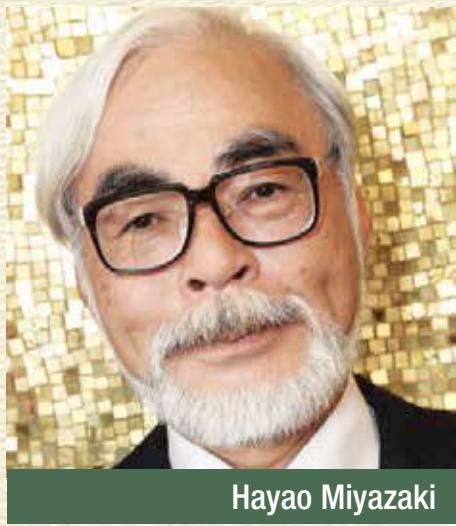
This book covers flora and fauna in great detail along with tribes and National Parks with rare photographs which the author took himself, spanning a period of 20 years.

The speciality of the book is the mention of the present status of these species in the Red Book and the reasons for their decline.

I would put this book in the must read category!

- Sarath Babu S, Chennai

# IN FOCUS



Hayao Miyazaki

**“In order to grow your audience, you must betray their expectations.”**

- Hayao Miyazaki's whimsical style and boundless imagination have propelled him to legendary status and influenced a whole generation of *anime* fans.

## LEGACY

Hayao Miyazaki (born on 5 January, 1941) is the visionary Japanese animator who introduced mainstream audiences to the world of *anime*. He is also responsible for setting up Studio Ghibli, the most commercially successful and critically appreciated anime film production company worldwide.

Going from being a young boy unable to sketch a realistic human figure to being dubbed “the world’s greatest living animator” by John Lasseter, the Chief Creative Officer at Pixar; Miyazaki has left an indelible impression by becoming the only *anime* director to ever receive the Academy Honorary Award in 2015. His adherence to traditional, hand-drawn animation and refusal to tell simplistic stories is iconic.

Miyazaki set up Studio Ghibli with his long time collaborator, Isao Takahata, in 1984. Under the Ghibli banner, Miyazaki’s films fetched him a plethora of awards, including the Japanese Academy Award for Best Film. However, a distribution deal signed between Walt Disney and Ghibli’s parent company in 1996 brought Miyazaki worldwide acclaim.

Riding on this success, Miyazaki’s *Spirited Away* won the Best Animated Feature award at the 2003 Oscars. Ever since, Miyazaki continued to garner praise for his work, winning a Golden Lion at the Venice Film Festival and a BAFTA award until his final film, *The Wind Rises*, earned him his third Oscar nomination in 2013.

## DID YOU KNOW



My Neighbour Totoro, one of Studio Ghibli's earliest films



A scene from Spirited Away, Miyazaki's best received film.

- As an animator, Miyazaki is a purist, preferring to stick to hand-drawn animation rather than computer imagery. In 2008, he dissolved Studio Ghibli’s computer animation department.
- Miyazaki is famously opposed to war, and chose not to attend the Oscar ceremony in which *Spirited Away* won because America was invading Iraq at the time.
- Since his retirement, Miyazaki has been following his second great passion, manga. He is illustrating a serialised comic about samurais.
- Miyazaki’s father was the director of Miyazaki Airplane, a Japanese airplane manufacturing company. He credits his exposure to these machines in his youth to the fascinating mechanical contraptions seen in his films.

- Dushyant Shekhawat



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